Screening For Environmental Concerns At Sites With Contaminated Soil and Groundwater

Volume 1: Summary Tier 1 Lookup Tables

Prepared by:
California Regional Water Quality Control Board
San Francisco Bay Region
1515 Clay Street, Suite 1400
Oakland, California 94612

INTERIM FINAL - February 2005

Contact:
Roger C. Brewer, Ph.D.
Associate Engineering Geologist
Telephone: 1-510-622-2374
E-mail: rbrewer@waterboards.ca.gov

OR

Stephen Hill, Chief
Toxics Cleanup Division
Telephone: 1-510-622-2361
E-mail: shill@waterboards.ca.gov

California Regional Water Quality Control Board
San Francisco Bay
1515 Clay Street, Suite 1400
Oakland, California 94612

DISCLAIMER

This document, *Screening For Environmental Concerns at Sites With Contaminated Soil and Groundwater* (February 2005), is a technical report prepared by staff of the California Regional Water Quality Board, Bay Area Region (Board staff). This document is not intended to establish policy or regulation. The Environmental Screening Levels presented in this document and the accompanying text are specifically not intended to serve as: 1) a stand-alone decision making tool, 2) guidance for the preparation of baseline ("Tier 3") environmental assessments, 3) a rule to determine if a waste is hazardous under the state or federal regulations, or 4) a rule to determine when the release of hazardous chemicals must be reported to the overseeing regulatory agency.

The information presented in this document is not final Board action. Board staff reserve the right to change this information at any time without public notice. This document is not intended, nor can it be relied upon, to create any rights enforceable by any party in litigation in the State of California. Staff in overseeing regulatory agencies may decide to follow the information provided herein or act at a variance with the information, based on an analysis of site-specific circumstances.

This document will be periodically updated as needed. Please send comments, edits, etc. in writing to the above contacts. Board staff overseeing work at a specific site should be contacted prior to use of this document in order to ensure that the document is applicable to the site and that the user has the most up-to-date version available. This document is not copyrighted. Copies may be freely made and distributed. It is cautioned, however, that reference to the screening levels presented in this document without adequate review of the accompanying narrative could result in misinterpretation and misuse of the information.

Table of Contents

FIGURES

TABLES (ENVIRONMENTAL SCREENING LEVELS)

APPENDICES (IN VOLUME 2)

Executive Summary

This document presents Environmental Screening Levels (ESLs) for chemicals commonly found in soil and groundwater at sites where releases of hazardous chemicals have occurred. The ESLs replace screening levels presented in the previous edition of this document, entitled *Application of Risk-Based Screening Levels (RBSLs) And Decision Making to Sites With Impacted Soil and Groundwater* (December 2001). The change in terminology from "Risk-Based" screening levels to "Environmental" screening levels is intended to better convey the broad scope of the document and clarify that some screening levels are not "risk-based" in a strict toxicological definition of this term.

The ESLs are considered to be conservative. Under most circumstances, and within the limitations described, the presence of a chemical in soil, soil gas or groundwater at concentrations below the corresponding ESL can be assumed to not pose a significant, long-term (chronic) threat to human health and the environment. Additional evaluation will generally be necessary at sites where a chemical is present at concentrations above the corresponding ESL. Active remediation may or may not be required, however, depending on site-specific conditions and considerations. This document may especially be beneficial for use at sites with limited impacts, where the preparation of a more formal environmental assessment may not be warranted or feasible due to time and cost constraints.

The ESLs were developed to address environmental protection goals presented in the *Water Quality Control Plan for the San Francisco Bay Basin* ("Basin Plan," RWQCBSF 1995) of the San Francisco Bay Area Regional Water Quality Control Board (RWQCB). These goals include:

Surface Water and Groundwater:
- Protection of drinking water resources;
- Protection of aquatic habitats;
- Protection against vapor intrusion into buildings;
- Protection against adverse nuisance conditions.

Soil:
- Protection of human health (direct-exposure);
- Protection against vapor intrusion into buildings;
- Protection against leaching and subsequent impacts to groundwater;
- Protection of terrestrial biota;
- Protection against adverse nuisance conditions.

The ESLs are presented in a series of four lookup tables. Each table reflects a specific combination of soil, groundwater and land-use characteristics that strongly influence the magnitude of environmental concerns at a given site. This allows the user to select ESLs that are most applicable to a given site.

The ESL document presents a "tiered" approach to environmental risk assessments. Under "Tier 1", sample data are directly compared to ESLs selected for the site and decisions are made regarding the need for additional site investigation, remedial action or a more detailed risk assessment. In a "Tier 2" risk assessment, a selected component(s) of the Tier 1 ESL is modified with respect to site-specific considerations. An example may be the adjustment of a screening level for direct exposure with respect to an approved, alternative target risk level. Site data are then compared to the revised screening level as well as the remaining, unmodified components of the Tier 1 ESL. This provides an intermediate but still relatively rapid and cost-effective option for preparing more site-specific risk assessments. Risk assessment models and assumptions that depart significantly depart from those used to develop the Tier 1 ESLs are described in a more traditional, "Tier 3" risk assessment. The Tier 1 methodology can, however, still provide a common platform to initiate a Tier 3 risk assessment and help ensure that all potentially significant environmental concerns are considered.

The Tier 1 ESLs presented in the lookup tables are NOT regulatory "cleanup standards". Use of the ESLs and this document in general is intended to be entirely optional on the part of the regulated facility and subject to the approval of the case manager in the overseeing regulatory agency. The presence of a chemical at concentrations in excess of an ESL does not necessarily indicate that adverse impacts to human health or the environment are occurring; this simply indicates that a potential for adverse risk may exist and that additional evaluation is warranted. ESLs presented for chemicals that are known to be highly biodegradable in the environment may in particular be overly conservative for use as final cleanup levels (e.g., many petroleum-related compounds). Use of the ESLs as cleanup levels should be evaluated in view of the overall site investigation results and the cost/benefit of performing a more site-specific risk assessment.

Reliance on only the Tier 1 ESLs to identify potential environmental concerns may not be appropriate for some sites. Examples include sites that require a detailed discussion of potential risks to human health, sites where physical conditions differ drastically from those assumed in development of the ESLs (e.g., mine sites, landfills, etc., with excessively high or low pH) and sites where impacts pose heightened threats to sensitive ecological habitats. The latter could include sites that are adjacent to wetlands, streams, rivers, lakes, ponds or marine shoreline or sites that otherwise contain or border areas where protected or endangered species may be present. Potential impacts to sediment are also not addressed. (e.g., presence of endangered or protected species). The need for a detailed ecological risk assessment should be evaluated on a site-by-site basis for areas where significant concerns may exist. Notification to the Natural Resource Trustee Agencies (including the state Department of Toxics Substances Control and Department of Fish and Game and the federal Fish and Wildlife Service, Department of the Interior and National Oceanic and Atmospheric Administration) may also be required, particularly if the release of a hazardous substance may impact surface waters.

The ESLs should NOT be used to determine when impacts at a site should be reported to a regulatory agency. All releases of hazardous substances to the environment should be reported to the appropriate regulatory agency in accordance with governing regulations. The lookup tables will be updated on a regular basis, as needed, in order to reflect changes in the referenced sources as well as lessons gained from site investigations and field observations.

1

Introduction

1.1 Purpose

Preparation of detailed environmental risk assessments for sites impacted by releases of hazardous chemicals can be a time consuming and costly effort that requires expertise in a multiple of disciplines, including toxicology, geology, ecology, chemistry, physics and engineering, among others. For small-business owners and property owners with limited financial resources, preparation of such risk assessments can be time and cost-prohibitive.

As a means to partially address this problem, this document presents a series of conservative Environmental Screening Levels (ESLs) for soil, groundwater and soil gas that can be directly compared to environmental data collected at a site. Correlative screening levels for surface water are also provided. Screening levels for over 100 commonly detected contaminants are given in a series of "lookup" tables. The tables are arranged in a format that allows the user to take into account site-specific factors that help define environmental concerns at a given property.

Within noted limits, risks to human health and the environment can be considered to be insignificant at sites where concentrations of chemicals of concern do not exceed the respective ESLs. The presence of chemicals at concentrations above the ESLs does not necessarily indicate that a significant risk exists at the site. It does, however, generally indicate that additional investigation and evaluation of potential environmental concerns is warranted.

The introductory text of this document is kept intentionally brief with a focus on the use of the ERLs rather than technical details about their derivation. The latter is provided in the appendices of Volume 2.

1.2 Tiered Approach to Environmental Risk Assessments

This document presents a three-tiered approach to environmental risk assessment. Under "Tier 1", sample data are directly compared to ESLs selected for the site and decisions are made regarding the need for additional site investigation, remedial action or a more detailed risk assessment. A detailed understanding of the derivation of the screening levels is not required for use at this level.

Under "Tier 2", selected components of the models used to develop the Tier 1 ESLs are modified with respect to site-specific data or considerations. Examples include adjustment of the assumed depth to impacted groundwater in the Tier 1 indoor-air impact model or use of an approved, alternative target risk level for direct-exposure concerns. Site data are then compared to the revised screening level as well as the remaining, unmodified components of the Tier 1 ESLs. This provides an intermediate but still relatively rapid and cost-effective option for preparing more site-specific risk assessments.

Under Tier 3, the user employs alternative models and modeling assumptions to develop site-specific screening or final cleanup levels or quantitatively evaluate the actual risk posed to human and/or ecological receptors by the impacted media. Consideration of the methodologies and potential environmental concerns discussed in this document is still encouraged, however. This will help increase the comprehensiveness and consistency of Tier 3 risk assessments as well as expedite their preparation and review.

1.3 Comparison To Existing Screening Levels

The CalEPA Office of Environmental Health Hazard Assessment recently published California Human Health Screening Levels or “CHHSLs” for a number of common contaminants in soil and soil gas (CalEPA 2004a). The CHHSLs are essentially identical to Preliminary Remediation Goals or “PRGs” developed by Region IX of the U.S. Environmental Protection Agency and in use since the early 1990s (USEPA 2004). The City of Oakland (Oakland 2000) has also prepared lookup tables of Environmental Screening Levels for soil and water.

The Environmental Screening Levels or “ESLs” presented in this document represent an expansion of the USEPA PRGs (and by default, the CalEPA CHHSLs) and the City of Oakland screening levels to reflect the broader scope of environmental concerns put forth in the Regional Water Quality Control Board (RWQCB) Basin Plan (RWQCBSF 1995). Differences and similarities between the ESL document and lookup tables prepared by the other programs are summarized below.

1.3.1 OEHHA CHHSLs

1.3.1.1 Background

The CalEPA Office of Environmental Health Hazard Assessment (OEHHA) published “California Human Health Screening Levels (CHHSLs)” in a reported entitled *Proposed Methodology for Calculating Advisory Human-Exposure-Based Screening Numbers*

Developed to Aid Estimation of Cleanup Costs for Contaminated Soil (November 2004, CalEPA 2004a). Preparation of the CHHSLs was required under the California Land Environmental Restoration and Reuse Act (CLRRA 2002). An accompanying guidance document entitled *Use of California Human Health Screening Levels in Evaluation of Contaminated Properties* was also prepared (CalEPA 2005). The documents present human health-based screening levels for 50+ common contaminants in soil and/or soil gas. The CHHSLs are essentially identical to correlative soil and soil gas screening levels incorporated into the ELS lookup tables. A brief discussion of the CHHSLs is provided below. A comparison of CHHSLs and ESLs (as well as the USEPA Region IX PRGS) is provided in Appendix 9. CHHSLs were not developed for groundwater or surface water.

Soil CHHSLs for direct-exposure concerns were developed by OEHHA in coordination with the Department of Toxic Substances Control. Screening levels are presented for semi-volatile and nonvolatile chemicals. Models and exposure assumptions used are essentially identical to those used to develop the USEPA Region IX Preliminary Remediation Goals (see Section 1.3.2) as well as comparable ESLs (see Appendices 1 and 2). CalEPA toxicity factors and skin absorption factors were used in preference over USEPA factors when available. The same factors were incorporated into this edition of the ESLs, with only minor adjustments to affected screening levels. One exception is the (continued) use of a more conservative Hazard Quotient of 0.2 to calculate ESLs for noncarcinogens (versus 1.0 for both the CHHSLs and the PRGs). This is done in order to address potential cumulative health effects at sites with multiple contaminants. Cumulative effects must be evaluated on a site-by-site basis under both the CHHSLs and the USEPA PRGs.

The DTSC and OEHHA opted not to publish direct-exposure CHHSLs for volatile organic chemicals or “VOCs” (refer to Section 2.5 of CHHSLs guidance document). Screening levels for VOCs are, however, included in the ESL document (see Appendix 1). The ESL screening levels are based on the same model and exposure assumptions used to develop the USEPA Region IX Preliminary Remediation Goals, with the addition of CalEPA toxicity factors and an adjustment of the target Hazard Quotient for noncarcinogens (refer to Section 1.3.2 and Appendix 2).

Soil gas screening levels for potential vapor intrusion concerns are presented in the CHHSLs document (VOCs only). Staff with the San Francisco Bay Area Regional Water Quality Control Board as well as DTSC assisted in preparation of these screening levels. The screening levels were also developed using the same USEPA model as used to develop the soil gas screening levels presented in the ESL document (refer to Appendix 1) and referenced in the recent DTSC vapor intrusion guidance document (CalEPA 2004b). One difference is the use of a higher, assumed indoor-air exchange rates in the ESL model, due to the more moderate climate of the San Francisco Bay area (1.0 and 2.0 exchanges per hour for residences and commercial/industrial settings, respectively, versus 0.5 and 1.0 exchanges per hour referenced in the CHHSLs document; refer to

Appendix 1). As a result, soil gas screening levels presented in the CHHSLs document are roughly half of those presented in the ESL document at similar target risk goals for comparative site scenarios (see Appendix 9). For noncarcinogens, soil gas ESLs remain lower than comparable CHHSLs due to the more conservative target Hazard Quotient used.

1.3.1.2 Use of ESLs Versus CHHSLs

At sites overseen by the San Francisco Bay Regional Water Quality Control Board, the ESLs should continue to be used without modification. Soil, soil gas and indoor air screening levels essentially identical to the CHHSLs are already incorporated into the ESL document. While important, the CHHSLs do not address potential groundwater protection concerns and address only two of five environmental concerns potentially related to contaminated soil (refer also to Section 2.1 and Figure 1):

Environmental Concerns Addressed

	ESLs	CHHSLs
Groundwater Quality		
Drinking Water	YES	NO
Vapor Emission To Buildings	YES	NO
[1]Aquatic Receptors	YES	NO
[2]Gross Contamination	YES	NO
Soil Quality		
Direct Exposure	YES	YES
Vapor Emissions To Buildings	YES	NO
Leaching to Groundwater	YES	NO
Terrestrial Receptors	YES	NO
[2]Gross Contamination	YES	NO
Shallow Soil Gas		
Vapor Emission	YES	YES

1. Groundwater discharge to surface water.
2. Nuisances (odors, etc.), general resource degradation.

The CHHSLs should be thought of as one component of the ESLs, not as an alternative to the ESLs. Separate reference to the CHHSLs is not needed for use of the ESL document. Because the CHHSLs do not address the full scope of potential environmental concerns, they cannot be used as a stand-alone tool to evaluate contaminated sites (refer to Section 1.4 of CHHSLs guidance document). It is important to understand that, for many chemicals, the need to clean up contaminated soil may be environmental concerns other than direct exposure or vapor intrusion.

1.3.2 USEPA Region IX PRGs

The U.S. Environmental Protection Agency (USEPA) Region IX "Preliminary Remediation Goals" or "PRGs" are intended to address human health concerns regarding direct exposure with impacted soils (USEPA 2004). The equations used to develop the USEPA PRGs are generally consistent with human health risk assessment guidance prepared by the Department of Toxic Substances Control, including the CalTOX model (CalEPA 1994a) and the documents *Preliminary Endangerment Assessment Guidance Manual* (CalEPA 1994b) and *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a). As noted in Chapter 3, use of the CalTOX model and other CalEPA guidance documents and models may be necessary where more detailed risk assessments are required.

As discussed in the USEPA Region IX document, the PRGs are intended to address human direct-exposure with impacted soil and "...do not consider impact to groundwater or address ecological concerns." (USEPA 2004). Expansion of the USEPA PRGs in the lookup tables presented in this document includes:

- Modification of soil PRGs to reflect CalEPA-specific toxicity factors;
- Adjustment of PRGs for noncarcinogens to reflect a target hazard quotient of 0.2 to address potential cumulative health concerns;
- Addition of direct-exposure screening levels for construction and trench workers' exposure to subsurface soils;
- Addition of soil and groundwater screening levels for indoor-air impact concerns;
- Addition of groundwater screening levels for the protection of aquatic habitats/surface water quality;
- Use of a more rigorous leaching model to develop soil screening levels for protection of groundwater quality;
- Addition of soil screening levels for urban area, ecological concerns;
- Addition of soil and groundwater "ceiling levels" to address gross contamination and general resource degradation concerns; and
- Addition of soil and groundwater screening levels for Total Petroleum Hydrocarbons (TPH).

Use of the USEPA Region IX PRG models in the RWQCB lookup tables is discussed further in Section 3.2 of Appendix 1. A summary of the direct-exposure models is provided in Appendix 2.

1.3.3 City of Oakland Screening Levels

A brief comparison of the RWQCB and the City of Oakland approaches to the development of environmental screening levels is provided in Table 1-1. Since 1999, the City of Oakland has presented environmental screening levels for soil and groundwater through its Urban Land Redevelopment (ULR) Program. The ULR Program is a collaborative effort by the City of Oakland and the principal agencies charged with enforcing environmental regulations in Oakland to facilitate the cleanup and redevelopment of contaminated properties (Oakland 2000). It includes innovative institutional mechanisms for tracking residual contamination and ensuring long-term compliance with risk management plans. The ULR Program is coordinated by the City and is specific to Oakland sites.

The City of Oakland approach is based on the guidelines prescribed in *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* (ASTM 1995). The Guidance Document, Technical Background Document and other information on the Oakland ULR program is available on the internet at www.oaklandpw.com/ulrprogram. Modifications have been made to better address child exposure and recreational water use scenarios. In addition, many input values reflect Oakland-specific geologic, hydrogeologic and climatic conditions (Oakland Technical Background 2000 and updates). These values may not be appropriate for other areas within the RWQCB's jurisdiction.

The RWQCB has agreed that the Oakland look-up tables are appropriate for use at Oakland sites under the conditions and limitations discussed in the ULR Program Guidance (memo dated August 3, 2001; RWQCBSF 2001b). In particular, sites where surface or groundwater conditions present ecological, aesthetic, taste or odor concerns may require additional analysis. Active remediation to address these concerns may not be necessary at most sites in Oakland that are not near sensitive water bodies, however, due to its highly-developed, urban setting

1.3.4 Hazardous Waste Regulations

California Total Threshold Limit Concentrations (TTLC) criteria for solids and Soluble Threshold Limit Concentration (STLC) criteria for liquids should not in most cases be used as soil and groundwater screening or cleanup levels. The TTLC and STLC criteria are intended to determine the type of landfill a waste material must be sent to (Title 22, Section 66699 - Persistent and Bioaccumulative Toxic Waste). Where TTLC or STLC criteria are exceeded, the waste must in general be sent to a Class I, hazardous waste landfill. The criteria, developed in the 1980s, are only loosely based on human health and environmental considerations. STLC values in general reflect drinking water or surface water goals of the time, although some are clearly out-of-date (e.g. trichloroethylene STLC value of 204 mg/L). TTLC values were derived by simply multiplying the STLC value by ten (organic substances) or one hundred (metals).

In most cases, TTLC values exceed the most conservative environmental screening levels presented in this document. In the case of Endrin and DDT/DDE/DDD, however, the TTLC is somewhat lower than the screening levels for human health concerns. For example, the TTLC for combined DDT/DDE/DDD is 1.0 mg/kg while the residential, direct-exposure soil screening is 1.7 mg/kg. This presents the enigma that while soil impacted below 1.7 mg/kg is not considered to pose a significant risk to human health, it could be classified as a "hazardous waste" if it were excavated and transported offsite for disposal. Again, this is not a difference of opinion about the potential toxic effects of these chemicals, it is merely a reflection of the less rigorous development of the TTLC values.

Unfortunately, it is not anticipated that the TTLC and STLC values will be revised in the near future. To avoid potential future problems with soil disposal and even public perception, it may be prudent to use TTLCs as final cleanup values for sites where the TTLC is less than cleanup values based on actual risk to human health and the environment.

1.3.5 OSHA Standards Permissible Exposure Levels

The National Institute for Occupational Safety and Health (NIOSH) is the Federal agency responsible for conducting research and making recommendations for the prevention of work-related disease and injury, including exposure to hazardous chemicals in air (NIOSH 2003). NIOSH develops and periodically revises Recommended Exposure Limits (RELs) for hazardous substances in the workplace. The RELs are used to promulgate Permissible Exposure Levels (PELs) under the Occupational Safety and Health Act (OSHA).

In most cases, OSHA exposure limits are not appropriate for health risk evaluations for commercial settings where the chemical is not currently being used as part of a regulated, industrial process. This includes sites affected by the migration of offsite releases (e.g., via emissions from a moving plume of contaminated groundwater). OSHA limits are derived for an occupational setting, where the chemical in question is used in the industrial process, i.e., workers and others who might be exposed to the chemical have knowledge of the chemical's presence, receive appropriate health and safety training, and may be provided with protective gear to minimize exposures. OSHA limits are derived for adult, healthy workers and are not intended to protect children, pregnant women, the elderly, or people with compromised immune systems.

According to State Water Resources Control Board Resolution No. 92-49, Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304, the Regional Water Boards must set cleanup levels that protect the full range of people who might be exposed to contaminants in soil and groundwater, including sensitive receptors. This goes beyond adult, healthy workers for which OSHA limits are intended. OSHA limits are not intended to evaluate risks posed by involuntary exposures to the general public, where site residents and occupants generally do not expect to be exposed to chemicals from a vapor intrusion pathway, do not receive training on such exposure, and have no protective gear to minimize exposures. For all these reasons, the OSHA limits provide inappropriate indoor air targets for both residential and commercial land use scenarios.

As one example, the current OSHA PEL for tetrachloroethylene (PCE) is 678,000 ug/m^3 (100 ppmv, NIOSH 2003). Comparable risk-based screening levels for commercial/industrial exposure settings included in this document fall between 0.68 ug/m^3 and 10 ug/m^3 (carcinogenic effects vs noncarcinogenic effects, respectively; refer to Table E-3 in Appendix 1). The PEL is applicable to regulated work areas where PCE is being used and the employees have been properly trained to minimize exposure. The risk-based goals are applicable to all other areas.

1.3.6 RWQCB Basin Plan

The RWQCB Basin Plan ("Basin Plan") presents generic soil screening levels of 1.0 mg/kg total volatile organic compounds (VOCs) and 10 mg/kg semi-volatile organic compounds (SVOCs, RWQCBSF 1995). The Basin Plan states that the need to develop chemical-specific screening is to be evaluated on a site-by-site basis. As can be inferred from the detailed ESLs provided in Appendix 1, the Basin Plan screening level for total VOCs is probably adequate to overly conservative for gasoline-range petroleum fuel mixtures at most sites. Chemical-specific ESLs for benzene and MTBE are less than 1 mg/kg, due to their human toxicity and/or mobility in soil. The prevalence of less toxic and mobile VOCs in gasoline-range fuel mixtures (e.g., toluene, ethylbenzene, xylenes, etc.), however, would generally ensure that a total VOC screening level of 1 mg/kg adequately addresses concerns regarding these compounds in the absence of chemical-specific ESLs. The total VOC screening level is in all likelihood overly conservative for most heavier fuel mixtures that lack significant amounts of benzene and MTBE (e.g., diesel fuel).

For direct-exposure, human health concerns, the Basin Plan screening level of 1 mg/kg for total VOCs as presented in the Basin Plan is adequate to marginally over-conservative for the most commonly detected chlorinated solvents (e.g., tetrachloroethylene, trichloroethane, trichloroethylene, etc.). From a modeling perspective, the screening level may be somewhat under-conservative for potential leaching and groundwater protection concerns (e.g., see Appendix 1, Table G). The model used to generate screening levels for leaching of chemicals from soil conservatively assumes, however, that the impacted soil was situated within one meter of groundwater. At the vast majority of sites where this is the actual case, groundwater has already been impacted by the main mass of chemicals and direct monitoring provides a more accurate evaluation of leaching impacts. For sites where impacted soil is situated greater than 10 meters from groundwater, model-generated screening levels developed by other agencies suggest that a screening level of 1 mg/kg (or more) may be adequate for chlorinated VOCs (e.g., HIDOH 1995, 2005).

The Basin Plan screening level of 10 mg/kg for total semi-volatile organic compounds (SVOCs) is probably overly conservative for these compounds for groundwater protection purposes. For soils impacted with carcinogenic SVOCs, the Basin Plan screening level has traditionally been used in conjunction with human-health screening levels presented in the USEPA PRGs. The PRGs are also referenced in this document although with some modifications.

The Basin Plan references a total petroleum hydrocarbon (TPH) soil screening level of 100 mg/kg for the protection of drinking water resources. A similar screening level was developed for use in this document. As noted in the lookup tables and discussed in Appendix 1, however, this screening level is considered to be overly conservative for heavy, residual fuels (fuel oil #6, motor oil, etc.) as well as for use at sites that do not pose a direct threat to drinking water or surface water resources.

1.4 Chemicals Not Listed In Lookup Tables

The lookup tables list 100-plus chemicals most commonly found at sites with impacted soil or groundwater. Inclusion of ESLs for additional chemicals is a relatively straightforward process, provided that adequate supporting data are available. To obtain ESLs for chemicals not listed in the lookup tables, the interested party should contact the RWQCB staff noted at the beginning of this document. Development of ESLs will be carried out in the same manner as done for the listed chemicals. As an alternative, ESLs may be developed by qualified persons and submitted to the overseeing regulatory agency for review (refer to Section 3.0).

1.5 Limitations

The Tier 1 ESLs presented in the lookup tables are NOT required, regulatory "cleanup standards". Use of the ESLs as actual cleanup levels should be evaluated in view of the overall site investigation results and the cost/benefit of performing a more detailed environmental risk assessment. The ESLs are intended to be conservative for use at the vast majority of impacted sites in developed areas. As discussed in Chapter 3, however, use of the Environmental Screening Levels may not be appropriate for final assessment of all sites. Examples include:

- Sites that have a high public profile and warrant a detailed, fully documented environmental risk assessment;
- Sites where the depth to groundwater is less than 3.0m (ten feet; groundwater screening levels for vapor intrusion concerns may not be adequately conservative);
- Sites with high rainfall and subsequent high surface water infiltration rates (i.e., infiltration >720mm (28 inches) per year),

- Sites where inorganic chemicals (e.g., metals) are potentially mobile in leachate due to soil or groundwater conditions different than those assumed in development of the lookup tables (e.g., low pH at mine sites);

- Conservation areas where impacts pose heightened threats to ecological habitats (e.g., presence of endangered or protected species); and

- Sites where more than three known or suspected carcinogens or more than five chemicals with similar noncarcinogenic health effects have been identified.

- Sites affected by tides, rivers, streams, etc. where there is a potential for erosion and concentration of contaminants in aquatic habitats.

Examples of other site characteristics that may warrant a more detailed environmental risk assessment are discussed in Chapter 3 (refer also to discussion of screening levels in Appendix 1). In such cases, the information provided in this document may still be useful for identification of potential environmental concerns and development of strategies for preparation of a more site-specific risk assessment.

ESLs for chemicals that are known to be highly biodegradable in the environment may in particular be overly conservative for use as final cleanup levels. For example, final soil ESLs for Total Petroleum Hydrocarbon (TPH) and many noncarcinogenic, petroleum-related compounds (e.g., xylenes) are driven by the protection of groundwater quality. If long-term monitoring demonstrates that actual impacts to groundwater are insignificant then less stringent soil (and groundwater) screening levels may be warranted. Additional guidance regarding the management of impacted soil and groundwater at petroleum-release sites is provided in the following documents (refer also to overseeing regulatory agency):

- *Interim Guidance on Required Cleanup at Low-Risk Fuel Sites* (RWQCBSF 1996);

- Guidelines for Investigation and Cleanup of MTBE and Other Ether-Based Oxygenates (SWRCB 2000).

Copies of these documents can be obtained from the RWQCB.

Soil ESLs do not consider potential water- or wind-related erosion and deposition of contaminants in a sensitive ecological habitat. They also do not consider issues potentially related to anticipated Total Maximum Daily Load regulations (TMDLs). This may especially be of concern for metals and pesticides that are only moderately toxic to humans but highly toxic to aquatic and terrestrial biota (e.g., copper). The RWQCB *Erosion and Sediment Control Field Manual* provides practical information on the mitigation of erosion and runoff concerns.

It is conceivable that soil, groundwater and soil gas screening levels for the emission of chlorinated, volatile organic compounds to indoor air concerns may not be adequately conservative in some cases. This is most likely to occur at sites where the vapor permeability of vadose-zone soils is exceptionally high (e.g., highly fractured bedrock, gravels, etc.) and/or where building designs, ventilation systems and local environmental conditions otherwise lead to higher-than-expected vapor flow rates through foundations (e.g., houses with heating systems in basements). As discussed in Appendix 1, conservative target risks are used in part to address these uncertainties.

Table 1-1. Comparison of RWQCB and Oakland Risk-Based Approaches

		RWQCB	[1]Oakland
General Approach	Tiers	One tier of look-up tables. Includes separate screening levels for indoor air concerns based on soil type.	Two tiers of look-up tables: Tier 1 table applicable at any Oakland site; Tier 2 tables (3) account for site-specific soil types (Merritt Sands, sandy silts, and clayey silts) and alternate target risk. Tier 3 spreadsheets provided.
	Target Cancer Risk Level	10^{-6}	10^{-6} for Tier 1; 10^{-5} for Tier 2.
	Target Noncancer Hazard Quotient	0.2 (with option for site specific adjustment)	1.0 (with requirement to address cumulative risk as necessary)
	Ceiling/Nuisance Levels	"Ceiling levels" to address gross contamination concerns, nuisances, free-product mobility, and general resource quality	No "ceiling levels"; recommends removal of mobile or potentially-mobile free product.
	Total Petroleum Hydrocarbons	Screening levels for TPH included	No TPH screening levels.
Soil Pathways	Definition of "Shallow" Soils	0-3 meters below ground surface.	0-1 meter below ground surface.
	Direct Exposure, Inhalation of Volatiles	USEPA PRG model (USEPA 2004). Assumes "infinite" source thickness for volatile organic compounds.	ASTM (1995) model. Assumes infinite source unless mass balance conditions violated based on 1.0 m thick source.
	Ecological Concerns	Screening levels for terrestrial biota included (shallow soils only).	Recommends site-specific analysis when significant ecological habitats are threatened.
	Deep Soils	Direct-exposure soil screening levels for Construction/ Trench Worker exposure scenario.	No screening levels for this scenario; recommends a site-specific analysis as warranted.
Groundwater	Leaching Model	Employs the SESOIL model.	Employs the ASTM (1995) model.
	Leaching of Inorganic Compounds	No soil screening levels; recommends laboratory tests.	Soil screening levels for inorganic compounds, based on a neutral pH.
	Surface Water Protection	Groundwater screening levels for the ecological and aesthetic protection of surface water.	Screening levels for recreational use of groundwater and surface water. Recommends site-specific analysis of ecological and aesthetic concerns as warranted.
Indoor Air	Thickness of Soil Source	Assumes five meters. Recommends site-specific analysis as warranted.	Assumes "infinite" source thickness.
	Convective Flow	Incorporates convective flow in indoor-air impact model.	Does not incorporate convective flow (i.e., assumes no pressure differential) in indoor-air impact model.
	Surface Soil Screening Levels	Includes screening levels for protection of indoor air for both surface and subsurface soils.	Recommends site-specific analysis and controls for shallow soils (<1m) and use of screening levels for deeper soils.
	Soil Gas	Includes screening levels for soil gas.	Not included.

1. *Oakland Risk-Based Corrective Action: Technical Background Document: City of Oakland, Environmental Services Division*, January 2000 (and updates), www.oaklanddpw.com/urlprogram.

2

Tier 1 Lookup Tables

2.1 Organization of Lookup Tables

Environmental risk assessments may be carried out in either a "forward" mode, where actual risks are quantified based on concentrations of a chemical in an impacted media, or "backward" mode, where acceptable concentrations of a chemical in a given media are developed based on specified, target goals. The Environmental Screening Levels (ESLs) presented in this document represents an example of the latter. Tier 1 ESLs for soil and groundwater are summarized in Tables A through E. Each ESL in the tables collectively addresses environmental concerns stated or inferred in the *Water Quality Control Plan for the San Francisco Bay Basin* ("Basin Plan," RWQCBSF 1995), prepared by the San Francisco Bay Area Regional Water Quality Control Board (RWQCB). These concerns include:

Groundwater Quality:
- Protection of human health
  - Current or potential drinking water resource;
  - Emission of subsurface vapors to building interiors;
- Protection of aquatic receptors (discharges to surface water);
- Protection against gross contamination concerns (nuisance, odors, etc.) and general resource degradation.

Soil Quality:
- Protection of human health
  - Direct/indirect exposure to impacted soil (ingestion, dermal absorption, inhalation of vapors and dust in outdoor air);
  - Emission of subsurface vapors to building interiors;
- Protection of groundwater quality (leaching of chemicals from soil);
- Protection of terrestrial (nonhuman) receptors;
- Protection against gross contamination concerns (nuisance, odors, etc.) and general resource degradation.

Shallow Soil Gas:
- Protection of human health
  - Emission of subsurface vapors to building interiors.

For the purpose of this document, "soil" refers to any unlithified material in the unsaturated zone that is situated above the capillary fringe of the shallowest saturated unit. A summary of environmental concerns considered in the ESLs is depicted schematically in Figure 1. This is correlative to a "conceptual site model" prepared for a detailed environmental risk assessment. The degree to which any given concern will "drive" environmental risk at a site depends on the actual potential for exposure and the toxicity and mobility of the chemical.

Site characteristics that play an important role in evaluating potential environmental concerns or developing site-specific cleanup levels include:

- Physical location of the impacted soil (e.g., currently or potentially exposed at the ground surface versus isolated in the subsurface);
- Beneficial use of the groundwater immediately underlying the site or otherwise potentially threatened by the release (e.g., drinking water resource threatened versus no drinking water resource threatened);
- Current and anticipated future use of the site (e.g., residential land use permitted or commercial/industrial land use only).

In order to include consideration of these site characteristics in the ESLs, four different tables were prepared (Tables A through D). Each table reflects varying combinations of site characteristics:

- Table A – Shallow soils, potential drinking water resource threatened;
- Table B – Shallow soils, potential drinking water resource not threatened;
- Table C – Deep soils, potential drinking water resource threatened;
- Table D – Deep soils, potential drinking water resource not threatened;

Each of the tables provides separate soil screening levels for residential (i.e., unrestricted) and commercial/industrial land-use scenarios.

For each chemical listed in the lookup tables, screening levels were selected to address each applicable environmental concern under the specified combination of site characteristics. The lowest of the individual screening levels for each concern was selected for inclusion in the summary Tier ESL tables presented in Volume 1 of this document. This ensures that the ESLs presented in these tables are protective of all potential environmental concerns and provides a tool for rapid screening of site data.

Where ESLs are exceeded, the detailed tables provided in Appendix 1 can be used to identify the specific environmental concerns that may be present at the site.

An example of the selection of summary, Tier 1 ESLs for tetrachloroethylene (PCE) is presented in Figure 2 (surface soils, drinking water resource threatened, unrestricted land use desired). A more detailed discussion of this example is provided in Appendix 1.

2.2 Use of Lookup Tables

The step-by-step use of the lookup tables is summarized below and discussed in more detail in the following sections. A summary of the process is also provided in Figure 3. An outline and discussion of information that should be included in a Tier 1 environmental risk assessment is provided in Section 2.11.

Step 1 - ESL Updates and Applicability

Check with the overseeing regulatory agency to determine if the ESLs can be applied to the subject site. Ensure that the most up-to-date version of this document is being used (updated every 1-2 years in general).

Step 2: Identify All Chemicals of Potential Concern

An environmental risk assessment must be based on the results of a thorough site investigation, where all chemicals of potential concern have been identified. A summary of the site investigation results should be included in the risk assessment in order for it to be reviewed as a "stand alone" document." A general outline of site investigation information that should be included in a Tier 1 risk assessment is provided in Section 2.11.

Step 3: Select Lookup Table(s)

Determine the designated beneficial use of impacted or threatened groundwater beneath the site. In general, all groundwater must initially be treated as a current or potential source of drinking water (see Section 2.4). Next, determine the depth below ground surface to the top of impacted soil (see Section 2.5). This site information is then used to select the most appropriate lookup table (see Figure 3).

Steps 4: Determine Desired Land Use (soil ESLs only)

ESLs for soil are selected based on the present and desired future use of the site. Two options are provided in the lookup tables, "Residential Land Use " or "Commercial/Industrial Land Use Only". Screening levels for residential land used are considered to be adequate for unrestricted use of a property. **For evaluation of commercial/industrial properties, it is highly recommended that site data be compared to ESLs for both unrestricted/residential and commercial/industrial land use.** Reference only to ESLs for commercial/industrial land use will in most cases require that a covenant to the deed be prepared that restricts use of the property to these purposes only (see Section 2.10).

Steps 5 and 6: Select Soil and/or Groundwater ESLs

Based on the desired land use(s), select appropriate soil ESLs. ESLs for groundwater are provided in the adjacent column of each table and are not dependent on land use or depth to impacted soil. Correlative screening levels for surface water are also provided. Replace ESLs with naturally occurring, background concentrations of chemicals of concern (e.g., arsenic) or laboratory method reporting levels if higher (see Section 2.9).

Step 7: Determine Extent of Impacted Soil and/or Groundwater

Using the selected ESLs, determine the extent of impacted soil or groundwater and areas of potential environmental concern at the site and offsite, as required. Soil data should be reported on a dry-weight basis (see Appendix 1, Section 6.2). The use of data from filtered groundwater samples is generally acceptable, although this should be confirmed with the overseeing regulatory agency. For sites where sample data are limited, it will be most appropriate to compare the maximum-detected concentrations of chemicals of concern to the ESLs. For sites where an adequate number of data points are available, the use of statistical methods to estimate more site-specific exposure point concentrations and evaluate environmental risks may be appropriate. The exposure point concentration is generally selected as the lesser of the maximum-detected concentration and the 95% upper confidence interval of the arithmetic mean of sample data. Guidance for the estimation of exposure point concentrations, use of "non-detect" data, and other issues is provided in the documents *Preliminary Endangerment Assessment Guidance Manual* (CalEPA 1994b), *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a) and *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (USEPA 2002), among other sources. As discussed in these documents, sample data collected outside of impacted areas should generally not be included in estimation of exposure point concentrations. **For residential land use scenarios, soil sample data should be averaged over no more than a $100m^2$ (1,000 ft^2) area. For commercial/industrial areas, soil data may be averaged within known or anticipated outdoor work areas, if needed. For vapor intrusion concerns, groundwater, soil and/or soil gas data should not be averaged over the floor space area of existing or anticipated buildings.**

Steps 8 and 9: Evaluate The Need For Additional Investigation or Corrective Actions; Submit Appropriate Reports

Based on a comparison of available site data to the ESLs, evaluate the need for additional action at the site (e.g. additional site investigation, remedial action, preparation of a more site-specific risk assessment, etc.). This is then summarized in the Tier 1 Environmental Risk Assessment report and workplans for additional corrective actions as needed (see Section 2.11). Decisions for or against additional actions should always be made in conjunction with guidance from the overseeing regulatory agency.

2.3 Evaluation of Petroleum Contamination

Contamination of soil, water and air with petroleum mixtures is evaluated in terms of both Total Petroleum Hydrocarbon (TPH) and target "indicator chemicals" for the given petroleum mixture. A more detailed discussion is provided in Appendix 1. Indicator chemicals typically recommended for petroleum mixtures include (after CalEPA 1996a):

Monocyclic Aromatic Compounds (primarily gasolines and middle distillates)
- benzene
- ethylbenzene
- toluene
- xylene

Fuel additives (primarily gasolines)
- MTBE
- other oxygenates as necessary

Polycyclic Aromatic Compounds (primarily middle distillates and residual fuels)
- methylnaphthalene (1- and 2-)
- acenaphthene
- acenaphthylene
- anthracene
- benzo(a)anthracene
- benzo(b)fluoranthene
- benzo(g,h,i)perylene
- benzo(a)pyrene
- benzo(k)fluoranthene
- chrysene
- dibenzo(a,h)anthracene
- fluoranthene
- fluorene
- indeno(1,2,3)pyrene
- naphthalene
- phenanthrene
- pyrene

The TPH ESLs should be used in conjunction with ESLs for these chemicals. As discussed in Appendix 1, the "middle distillates" category of TPH includes diesel fuel kerosene, stoddard solvent, home heating fuel, jet fuel and similar petroleum mixtures. "Residual fuels" includes heavy petroleum products such as No. 6 fuel oil ("Bunker C"), lubricating oils, “oil and grease,” "waste oils" and asphalts. Soil and groundwater impacted by releases of waste oil may also require testing for heavy metals and chemicals such as chlorinated solvents and PCBs. Screening levels for these chemicals are included in the lookup tables.

Trimethylbenzenes, butylbenzenes, methylnaphthalenes and a number of other common constituents of petroleum products (especially gasolines) are sometimes reported separately in analyses of contaminated soil and groundwater. In general, these constituents should be collectively evaluated under "TPH" and do not need to be evaluated separately. A brief summary of common constituents of gasoline is provided in the New England Interstate Water Pollution Control Commission Leaking Underground Storage Tank bulletin No. 44 (NEIWPCC 2003).

2.4 Groundwater Beneficial Use

As stated in the San Francisco Bay Region *Water Quality Control Pla*n ("Basin Plan", RWQCBSF 1995), "Unless otherwise designated by the Regional Board, all groundwaters are considered suitable, or potentially suitable, for municipal or domestic water supply." All groundwater beneath a given site should be initially treated as a potential source of drinking water unless otherwise approved by the RWQCB office. For the purposes of this document, it is also assumed that all shallow groundwater will ultimately discharge to a body of surface water and potentially impact aquatic organisms (see Section 2.7). Soil and groundwater ESLs were therefore developed to be protective of both drinking water resources and aquatic habitats. This is discussed in greater detail in Chapters 2 and 3 of Appendix 1.

The Basin Plan recognizes that site-specific factors may render groundwater unsuitable for potential drinking water purposes. Tables B and D in this document are intended for use at such sites. The ESLs presented in these tables consider the potential discharge of groundwater to surface water but do not consider potential impacts to sources of drinking water. The ESLs also consider "gross contamination" issues such as the presence of free product and aesthetic or odor problems. Use of these tables for screening level environmental risk assessments must be approved by the RWQCB but may not necessarily require regulatory "de-designation" of groundwater beneficial use.

Hydrogeologic criteria presented in the Basin Plan for potential exclusion of a given occurrence of groundwater from consideration as a potential source of drinking water typically include:

- Total dissolved solids in groundwater is greater than or equal to 3,000 mg/L; OR

- Water bearing unit is not sufficiently permeable to produce an average, sustained yield of 200 gallons of water per day.

Groundwater in coastal areas, geothermal fields, etc., may contain levels of dissolved solids that make the water unsuitable as a potential source of drinking water. In addition, the permeability of soils and sediments that lack a significant amount of coarse-grained material (or fractures, in the case of bedrock) may be too low to allow for an adequate, sustained yield of groundwater. Unconsolidated geologic units that are comprised of less than 20% sand-size (or larger) material or more than 30% clay-size material are typically not considered to be viable "aquifers" or potential sources of useable groundwater (inferred from Fetter 1994). The potential for a given unit of bedrock to serve as a viable source of groundwater similarly depends on the primary and secondary porosity in the rock and the quality of the groundwater. Consideration must also be made for the potential migration of groundwater out of a geologic unit that in itself is insufficiently permeable to be considered to be an aquifer and into a more permeable unit that could serve as a viable source of drinking water.

In general, soil and groundwater screening levels are more stringent for sites that threaten a potential source of drinking water (e.g., compare Tables A and B). This is particularly true for chemicals that are highly mobile in the subsurface and easily leached from impacted soil. For chemicals that are especially toxic to aquatic life (e.g., several long-chain hydrocarbons, pesticides and heavy metals), however, screening levels for sites that threaten drinking water resources may be driven by surface water/aquatic habitat protection concerns. This is discussed in more detail in Appendix 1.

2.5 "Shallow" Versus "Deep" Soils

For the purposes of this document, a depth of three meters (approximately 10 feet) was used to delineate between “shallow” soils, where a potential exists for regular direct exposure of residents and/or office workers, and "deep" soils where only periodic exposure during construction and utility maintenance work is considered likely. This is consistent with guidance presented in the CalEPA document *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a) and is regarded as the maximum, likely depth that impacted soil could at some point in the future be excavated and left exposed at the surface during typical redevelopment activities. The potential for deeper soils to be brought to the surface in the future should be evaluated on a site-by-site basis based on planned redevelopment or maintenance activities.

The full suite of environmental concerns noted in Figure 1 was considered in development of ESLs for shallow soils. For deep soils, regular exposure of residents or commercial/industrial workers and impacts to terrestrial flora and fauna was not considered. As a result, ESLs for relatively non-mobile chemicals are generally less stringent for deep soils than correlative ESLs for shallow soils (e.g., compare PCB ESLs in Tables A and C). For chemicals that are easily leached from soil or potentially emitted to the air as a volatile gas, however, groundwater and indoor-air protection concerns usually drive selection of the final ESL regardless of the depth of the impacted soil. This is the case for several of the highly volatile, chlorinated organic compounds. As a result, correlative shallow and deep soil ESLs are identical (e.g., compare trichloroethylene ESLs in Tables A and C).

If impacted soil extends across the three-meter dividing line between shallow soil and deep soil, it may be appropriate to use a separate set of screening levels for each zone (e.g., Table A for the shallow soils and Table C for the deep soils). As discussed in Section 2.10, however, the pros and cons of remediating deep soils to shallow soil criteria should be evaluated on a site-by-site basis. This may help avoid concerns regarding future disturbance and reuse of deeper soils.

As another alternative, the less stringent ESLs for deep soils could be applied to shallower soils under a Tier 2 or Tier 3 risk assessment (refer to Chapter 3), provided that appropriate actions to prevent future exposure and unmanaged reuse are taken. Such controls may include (but not necessarily be limited to):

- placement and maintenance of adequate cap or other risk-management measures to eliminate potential direct exposure;
- modeling and/or direct field measurement to evaluate potential impacts to indoor air due to vapor emissions; and
- preparation of a risk management plan and other appropriate institutional controls (e.g., deed restrictions) in order to prevent unauthorized disturbance of the soil in the future and allow for appropriate management of the soil if it is exposed.

Capping of shallow, contaminated soil and other engineered controls used in place of full cleanup are generally not allowed for properties that are to be used for single-family homes. The need to consider these actions at sites with impacted soils situated more than three meters below the ground surface should be discussed with the overseeing regulatory agency on a site-by-site basis.

2.6 Land Use

Land uses are categorized based on the assumed length, duration and magnitude of potential human exposure. The category "Residential Land Use" is intended for use at sites where future land-use restrictions are not desirable or allowed. This includes sites to be used for residences, hospitals, day-care centers and other sensitive purposes (e.g., refer to CalEPA 2002). ESLs listed under this category incorporate conservative assumptions regarding long-term, frequent exposure of children and adults to impacted soils in a residential setting (see Appendices 1, Section 3.2 and Appendix 2). In contrast, the land-use category "Commercial/Industrial Use Only" assumes that only working age adults will be present at the site on a regular basis. Direct-exposure assumptions incorporated into the soil ESLs are somewhat less conservative than assumptions used in the residential land-use scenario.

Land use should be selected with respect to the current and foreseeable future use of the site in question. Reference to adopted General Plan zoning maps and local redevelopment plans is an integral part of this process. Use of the lookup tables for sites with other land uses (e.g., agriculture, parkland, etc.) should be discussed with and approved by the overseeing regulatory agency. As the category heading implies, use of the soil ESLs listed under "Commercial/Industrial Use Only" places implicit land-use restrictions on the affected property. While this may be considered acceptable for properties currently zoned for such purposes, the need for such restrictions in the future should be seriously weighed against the cost-benefit of remediating the property to meet the sometimes more conservative but less restrictive ESLs for unrestricted land use. Implications for land-use restriction are discussed in more detail in Section 2.10.

A 2003 amendment to the Porter-Cologne Act (Section 13307.1(c)) requires that formal land-use restrictions be placed on sites that are not remediated to an extent that allows unrestricted future use (e.g., residential, day care, etc.). This rule does not currently apply to sites regulated under the state underground storage tank program. It is anticipated that this rule will be especially applied to non petroleum-impacted sites.

2.7 Threat To Surface Water Habitats

Screening levels for freshwater, marine and estuarine water bodies are presented in Table F. These screening levels consider the same set of environmental concerns as groundwater (excluding potential impacts to indoor air), with the addition of screening levels for the potential bioaccumulation of chemicals in aquatic organisms and subsequent human consumption of these organisms. In the Bay area, the areas north of the Dumbarton Bridge and west of the Richmond-San Rafael Bridge are considered to be marine. Screening levels for estuarine environments are based on the more stringent of screening levels for marine versus freshwater environments. The areas south of the Dumbarton Bridge and east of the Richmond-San Rafael Bridge to the upstream extent of tidal influences are considered to be estuarine. Tidally influenced portions of creeks, rivers and streams flowing into the Bay between these areas should also be considered to be estuarine in screening level assessments. Screening levels for estuarine environments are based on the more stringent of screening levels for marine versus freshwater environments but do not consider drinking water goals.

For the purposes of the Tier 1 lookup tables, it is assumed that impacted or potentially impacted groundwater at all sites could at some time migrate offsite and discharge into a body of surface water. This could occur due to the natural, downgradient migration of groundwater or to human activities such as dewatering of construction sites. For several pesticides and heavy metals, including dieldrin, endrin and endosulfan, aquatic habitat goals are more stringent than drinking water toxicity goals for humans. This is reflected in the final groundwater screening levels (refer also to Appendix 1).

The groundwater screening levels for potential impacts to aquatic habitats do not consider dilution of groundwater upon discharge to a body of surface water. Benthic flora and fauna communities situated below or at the groundwater/surface water interface are assumed to be exposed to the full concentration of chemicals in impacted groundwater. Use of a generic "dilution factor" to adjust the surface water protection screening levels with respect to dilution of groundwater upon discharge to surface water was therefore not considered. Consideration of dilution/attenuation factor and alternative groundwater screening levels for the protection of surface water quality may, however, be appropriate on a site-specific basis.

Consideration of surface water standards for bioaccumulation concerns in groundwater investigations and cleanup actions may be warranted at sites where large plumes of impacted groundwater threaten to cause long-term impacts to important aquatic habitats. The bioaccumulation standards will generally not need to be considered at sites with small, isolated plumes of impacted groundwater located some distance from a body of surface water. Although these plumes could conceivably migrate offsite and discharge into a body of surface water in the distant future, impacts are likely to be short-lived and the plumes are likely to become significantly diluted as they mix with surface water. The need for a more detailed study of potential groundwater impacts on surface water with respect to bioaccumulation of chemicals in aquatic organisms should be evaluated on a site-by-site basis. This may include the need for more stringent soil cleanup levels (to prevent additional leaching) and development of a more comprehensive, ecological risk assessment.

The soil and groundwater screening levels presented in the lookup tables do not directly address the protection of sediment quality. Site-specific concerns could include the accumulation and magnification of concentrations of highly sorptive chemicals in sediment over time due to long-term discharges of impacted groundwater. This may be especially true for groundwater impacted with highly sorptive (lipophyllic) chemicals, including heavy petroleum products.

Potential erosion and runoff of surface soils from impacted sites may also need to be considered, particularly at sites impacted with metals and pesticides that are situated near a sensitive body of surface water. The need for a more detailed, ecological risk assessment of impacts to sediment should be evaluated on a site-by-site basis and discussed with the overseeing regulatory agency.

2.8 Screening For Vapor Intrusion Concerns

2.8.1 General Nature of Vapor Intrusion

Detailed discussions of subsurface vapor intrusion into buildings is provided in the USEPA document *User's Guide For Evaluating Subsurface Vapor Intrusion Into Buildings* (USEPA 2003), the OEHHA document *Human Exposure Based Screening Numbers* (CalEPA 2004a) and the DTSC document *Guidance For The Evaluation Of The Vapor Intrusion To Indoor Air Pathway* (CalEPA 2004b, updated January 2005).

Volatile organic chemicals (VOCs) can be emitted from contaminated soil or groundwater and intrude overlying buildings, impacting the quality of indoor air. While actual impacts to indoor air can vary widely from building to building, and even within buildings, it is generally possible to estimate "worst case" scenarios for use in screening level risk assessments. The development of soil, soil gas and groundwater screening levels were developed for this purpose and incorporated into the ESLs A summary of approaches used to develop the screening levels is included in Appendix 1.

Heating, ventilation and air conditioning systems ("HVAC" systems), basements, strong winds and other factors can exacerbate vapor intrusion problems by reducing internal air pressure and creating a "vacuum effect" that enhances the advective flow of vapors through building floors (e.g., USEPA 2003, CalEPA 2004b). For buildings with a slab-on-grade design, this can result in the direct flow of subsurface vapors into a building with little or no dilution beforehand. The vapors become diluted as they mix with fresh air being drawn in through the buildings HVAC system or through open doors and windows (generally by a factor of 500 to 1,000 for residential buildings and higher for commercial/industrial buildings, see Appendix 1).

For buildings with a crawl space design, subsurface vapors are diluted as they diffuse into and mix air in the crawl space below the building floor. Additional mixing may or may not occur as the air from the crawl space is pulled into the building. "Vapor flux" through the building floor could be significantly elevated in comparison to slab-ob-grade design buildings due to the operation of an HVAC systems in poorly ventilated rooms (e.g., an unvented closet). This issue is still being evaluated. An initial review of published literature and site data, however, suggests that ultimate soil gas-to-indoor air attenuation factors can be very similar to slab-on-grade design buildings.

The field of vapor intrusion investigations is still evolving. Approaches to site investigations and evaluation of vapor intrusion concerns presented in guidance documents noted above and discussed below should not be taken as stringent requirements that must be applied at all sites. Appropriate investigation and risk assessment needs should be determined on a site-by-site basis. Ultimate requirements could be less or more stringent than that presented.

2.8.2 Screening For Vapor Intrusion Concerns In The Field

2.8.2.1 Stepwise Approach To Vapor Intrusion Evaluation

The direct collection and analysis of indoor air samples may seem to be an easy way to evaluate vapor intrusion concerns. Identification of the source of any VOCs identified is complicated by the presence of the same chemicals in auto emissions and many household goods (aerosol sprays, dry-cleaned clothing, cleaners, etc.), however. For example, ambient levels of benzene in outdoor air in the San Francisco Bay area (related to auto exhaust) typically exceed the indoor air screening level presented in Table E

(0.085 ug/m^3) by an order of magnitude or more (e.g., Air Resources Control Board, CalEPA 2004c). Ambient levels of dry cleaning solvent (tetrachloroethylene) and other chlorinated solvents in indoor air may also exceed the screening levels presented in Table E.

As an alternative, the sequential collection and evaluation of groundwater data or soil data (see below), soil gas data and, if needed, indoor air data is recommended. These data can then be compared to screening levels for vapor intrusion concerns presented in this document and areas of elevated concern quickly identified. The following approach is recommended (refer also to CalEPA 2004b):

1) Compare soil and/or groundwater data to appropriate screening levels for vapor intrusion concerns (see Tables E-1a and E-1b of Appendix 1, use screening levels for groundwater overlain by high-permeability soils); for sites with significant impacts to vadose-zone soils, proceed directly to Step 2;

2) For areas where groundwater screening levels for vapor intrusion concerns are approached or exceeded or sites where significant releases to vadose-zone soils have occurred, collect shallow soil gas samples immediately beneath (preferred) or adjacent to buildings and compare results to soil-gas screening levels (refer to Table E in this volume or Table E-2 in Appendix 1).

3) At buildings where soil-gas screening levels for vapor intrusion concerns are approached or exceeded, further evaluate the need to carry out an indoor air study (Section 2.8.3).

A more detailed discussion is provided below and in the recent DTSC vapor intrusion guidance document. **Note that site data should in general not be averaged over an area greater than the existing or anticipated floor space area of buildings for initial evaluation of vapor intrusion concerns.**

The screening levels are based on scientific models for vapor intrusion into buildings as well as a growing body of data from actual field investigations. A detailed discussion of the screening levels is presented in Appendix 1. Methods used to develop the screening levels are similar to those used by OEHHA to develop soil gas screening levels for vapor intrusion concerns and recommended by DTSC in the guidance documents noted above (CalEPA 2004a, CalEPA 2004b, see also Appendix 1).

2.8.2.2 Collection and Evaluation of Groundwater Data

Groundwater data should be collected at all sites where significant releases of VOCs may have occurred and compared to screening levels presented in Appendix 1 of this document (Table E-1a, see also Tables F-1a and F-1b). Vapor emission rates are controlled by the concentration of VOCs in the uppermost part of the water table. Grab sample data from this zone are preferable over data from monitoring wells when available. This is due to potential mixing effects of groundwater in wells with long screens or with screens that do not span the top of the water table.

Screening levels for groundwater overlain by highly permeable vadose-zone soils are incorporated into the F-series tables in Appendix 1 and the summary tables presented at the end of this volume. Alternative screening levels for groundwater overlain by less permeable soils are also presented (Table E-1a). Experience in the Bay area has shown the former are more appropriate for use in screening level assessments.

The groundwater screening levels for vapor intrusion concerns are based on an assumed three-meter depth to groundwater (see Appendix 1). These screening levels may not be adequately conservative for use at sites characterized by a shallower water table. The need to develop more site-specific screening levels or proceed directly to soil gas sampling should be reviewed with the overseeing regulatory agency. Imported fill material or disturbed native soils should be considered to be highly permeable in site-specific assessments unless vapor flow data into existing buildings indicate otherwise. This is incorporated into the updated USEPA spreadsheets by use of a default vapor flow rate into buildings of five liters per minute per $100m^2$ of floor space (“Qsoil”).

2.8.2.3 Collection and Evaluation of Soil Gas Data

Soil gas samples should be collected at sites where groundwater data suggest potentially significant vapor intrusion concerns. The collection of soil gas data is discussed in the document *Soil Gas Advisory* prepared by DTSC and the Los Angeles Regional Water Quality Control Board (CalEPA 2003). Approaches to soil gas studies are also presented in the above-noted vapor intrusion guidance document prepared by DTSC (CalEPA 2004b).

Initial soil gas samples should be collected over the core of the groundwater plume and in nearby areas of concern (e.g., residential areas, nearby buildings, utility corridors, etc.). Ideally, samples should be collected immediately beneath the foundations of existing buildings (e.g., “subslab”). Samples should be collected from areas immediately adjacent to buildings (preferably paved) if it is impractical to collect subslab samples. In areas away from buildings or where buildings are to be constructed in the future, samples should be collected from a depth of 1.5m (five feet) below ground surface. Soil gas samples collected from depths less than 1.5m are considered unreliable due to the increased potential to draw in ambient, surface air (CalEPA 2004b). If site-specific modeling of vapor flow rates or indoor-air impacts is to be carried out, the collection of additional soil geotechnical data should be considered (soil grain-size analysis, moisture content and fraction organic carbon). The use of lab-based, soil vapor permeability data to override the default vapor flux rate (Qsoil) of 5 liters/minute (per $100m^2$ of ground floor area) used in the USEPA models is, however, discouraged. These tests often do not adequately take into account enhanced permeability due to soil heterogeneities, soil fractures, relict root structures, shallow fill material, disturbance during redevelopment, and other types of potential secondary permeability. Data collected from soils within 1.5m of the ground surface and well above the water table are especially pertinent in the models. The collection of deeper soil gas samples and soil-type data may also be useful in evaluating the lateral and vertical extent of VOCs in the subsurface.

Both subslab sample data and shallow soil gas data (i.e., $\leq$1.5m bgs) should be compared to the soil gas screening levels presented in Table E. Where screening levels are approached or exceeded, the need to carry out an indoor air study should be more closely evaluated. Approaches for determining when an indoor air study should be carried out are still being developed. The recent DTSC vapor intrusion guidance (CalEPA 2004b) recommends that an indoor air study be carried out if site-specific, soil-gas-to-indoor vapor intrusion models suggest that impacts to indoor air may exceed a cumulative excess cancer risk of 10^{-6} or a noncancer hazard index >1.0 (e.g., refer to CalEPA 2004b).

While this approach is generally appropriate for sensitive land use scenarios (e.g., residential, day care, etc.), it may be impractical in areas of high ambient outdoor air pollution. For example, the concentration of benzene and other auto exhaust-related contaminants in outdoor air can exceed risk-based screening levels by up to two orders of magnitude. In such cases, impacts to indoor air related to vapor intrusion from subsurface contamination can easily be masked by existing outdoor pollution. Sampling of indoor air would not be useful. Decisions for cleanup of contaminated soil and groundwater for vapor intrusion concerns should instead be based on an evaluation of soil gas data in conjunction with ideal, target indoor air goals (even if these goals cannot be currently met due to other sources of contamination, including vehicle exhaust in ambient air).

An alternative approach for determining when indoor air studies are needed at commercial/industrial (C/I) settings if a Soil Gas C/I ESLs are exceeded is described below:

Step 1. Confirm and Evaluate Soil Gas Data.

- Confirm soil gas data with a second round of sampling in targeted areas of potential concern (e.g., co-located with hot spots identified in first round of soil gas data collection and previously identified hot spots in soil and/or groundwater). If significant differences in reported concentrations of VOCs are reported at individual sample points and ESLs were exceeded in one or both sampling events, consider the installation of permanent vapor monitoring wells in a denser grid (e.g., 15m to 20m grid) and additional sampling until the range of potential site conditions is adequately defined. Statistical approaches may be required at sites where wide temporal variations in concentrations of VOCs in soil gas are identified.

- If soil gas ESLs for noncarcinogens are not exceeded and ESLs for carcinogens are not exceeded by more than one order of magnitude (equivalent to a target risk of 10^{-5}), then no further action is warranted (refer to Table E-2 in Appendix 1).

- If soil gas ESLs are exceeded by more than amounts noted above, use USEPA soil gas spreadsheet to calculate a site-specific, cumulative excess cancer risk and noncancer hazard index (USEPA 2003, see web address in references). For example, input site-specific building and soil type data into USEPA spreadsheet for each chemical of concern and add up the calculate risks and hazard indices. Input a default vapor flux rate of 5 L/min per $100m^2$ of floor space. Print out spreadsheet results for each chemical of concern; calculate cumulative risks and include in letter report with recommendations for additional actions (see Step 2). [Note that toxicity factors presented in USEPA spreadsheets must be adjusted to CalEPA values when available. See Table E-3 in Appendix 1 and Appendix 4. Spreadsheet protection password is "ABC."]

Step 2. Evaluate site-specific vapor intrusion risks.

- Site-specific, cumulative excess cancer risk $<10^{-5}$ and/or cumulative noncancer hazard index <1.0 (and potential impacts to indoor air less than existing pollution in ambient, outdoor air). Testing of indoor air not required. Install permanent vapor monitoring probes in areas of primary concern and test quarterly for a period of one year to confirm soil gas data. If concentrations of VOCs do not increase significantly (i.e., to exceed cumulative 10^{-5} excess cancer risk or HI>1.0), no further action is warranted under current site conditions. Additional evaluation may be warranted if building conditions change or if new buildings are constructed over impacted areas.

- Site-specific, cumulative excess cancer risk $>10^{-5}$ and/or cumulative noncancer hazard index >1.0. Install permanent vapor monitoring probes and resample soil gas. Carry out indoor air testing if an excess cancer risk of $>10^{-5}$ and/or a cumulative noncancer hazard index >1.0 is confirmed (refer to Section 2.8.3). If resampling of soil gas indicates a potential indoor air risk $<10^{-5}$ and/or cumulative noncancer hazard index <1.0, carry out quarterly monitoring for one year to confirm (see above).

The above approach for commercial/industrial settings is intended to be general guidance only and should not be used as a strict requirement. The appropriateness of the approach should be evaluated on a case-by-case basis.

2.8.2.4 Soil Gas and Tight Soils

At sites where soil gas samples cannot be collected using traditional methods due to tight soil conditions (e.g., wet, clayey soils), other approaches should be attempted. In many cases, simply moving the collection probe over a few feet from the initial location will address the problem. If problems still persist, the installation of temporary soil vapor probes encased in permeable sand packs and capped with a bentonite clay mixture can be considered (refer to CalEPA 2002). The diameter and depth of the vapor probe borehole should be adjusted to allow sufficient pore space for the collection of soil gas samples. Adequate time (generally several weeks) should be allowed for VOCs in the surrounding clays to equilibrate with soil gas in the vapor probe sand pack.

Passive soil gas sampling techniques may also prove useful in tight soils, provided that the actual concentrations of VOCs present can be quantified (e.g., recent advances in "Gore™ Sorbers). This approach has not been widely used the Bay area at this time and is still being evaluated. Where possible, both "active" and passive soil gas data should be collected in amenable areas of a site and used to verify the interpretation of passive soil gas data from areas where active data could not be collected.

At sites where groundwater is impacted with VOCs and the collection of soil gas data is simply not possible, groundwater data should be compared to conservative screening levels and the need to go directly to crawl space and/or indoor air sampling evaluated. At "soil only" sites, soil data should be similarly collected and compared to conservative screening levels (see below).

2.8.2.5 Use of Soil Matrix Data

Soil screening levels for potential vapor intrusion concerns are incorporated in the ESL lookup tables (see Appendix 1, Table A-D series and Table E-1b). At sites where minor releases of volatile chemicals have occurred (e.g., restricted spills around underground tank fill ports), direct comparison of soil screening levels to site data is generally acceptable. If soil screening levels are exceeded, the need to collect soil gas samples and further evaluate vapor intrusion concerns should be evaluated. **At sites where significant releases of volatile chemicals have occurred, the direct use of soil gas data in conjunction with soil data is strongly recommended.**

An advantage of the soil vapor intrusion model is the inclusion of "mass-balanced" considerations in the evaluation of potential long-term impacts to indoor air. As discussed in the following section, this issue is not included in the soil gas vapor intrusion models or corresponding screening levels. (Mass balance issues are also not considered in the groundwater models. The continued migration of contaminated groundwater from upgradient areas is assumed to provide an ongoing source of VOCs to areas of concern, however, and mass-balance issues are less relevant.)

2.8.2.6 Soil Gas and Mass-Balance Issues

At sites with high levels of VOCs in soil gas but a limited total mass of VOCs in soil, a mass balanced approach to the evaluation of vapor intrusion concerns may be appropriate. For example, it is not uncommon to find relatively high levels of PCE in soil gas immediately beneath the floors of dry cleaners but relatively little PCE in soil samples collected in the same area. Most of the PCE is in vapor phase, with very little total mass present. This is most likely related to the presence of dry soil with very little organic carbon directly under the floor of the building.

Based on soil gas data alone, the vapor intrusion models may predict unacceptable, long-term impacts to indoor air. The actual mass of VOCs present may be insufficient to maintain initial impacts over the full span of the exposure duration assumed in development of the screening levels, however. In such cases, the screening levels presented in could be overly conservative for evaluation of long-term, chronic health risk concerns and a more site-specific evaluation of vapor intrusion concerns may be warranted. Additional information on this subject is provided in Section 3.3.2 under Tier 2 assessments.

2.8.3 Collection and Evaluation of Indoor Air Data

The collection of indoor data will be necessary to further evaluate vapor intrusion concerns in some cases. The collection of indoor air data in absence of soil gas and, if applicable, crawl space is not recommended. Such data are critical in determining the source of any VOCs identified in indoor air. Guidance on the collection and evaluation of indoor air data is provided in the above-noted DTSC document (CalEPA 2004b) and will not be repeated in detail here. Additional information is available in the Massachusetts Department of Environmental Protection document *Indoor Air Sampling And Evaluation Guide* (MADEP 2002).

The DTSC guidance document provides a table of recommend actions at sites where impacts to indoor air are identified (CalEPA 2004b). A slightly modified version of that table is provided below:

*Indoor Air Sampling Results	Response	Activities
Risk: $<10^{-6}$ HI: <1.0	Minimal	Confirm that vapor intrusion impacts are not likely to increase in the future.
Risk: 10^{-4} to 10^{-6} HI: 1.0 to 3.0	Monitoring +/- Mitigation	Collect soil gas, indoor air and/or crawl space samples semi-annually as appropriate. Mitigation may be recommended in some cases to reduce exposure even though health risk goals may not be exceeded.
Risk: $>10^{-4}$ HI: >3.0	Mitigation Required	Institute engineering controls to mitigate exposure and collect soil gas samples and indoor air samples semiannually to verify mitigation of exposure.

*Contaminants identified in indoor air that are directly linked to the intrusion of subsurface vapors.
Risk = Cumulative excess cancer risk
HI = Hazard Index – Cumulative risk posed by sum of noncancer hazard quotients of specific chemicals of concern.

If buildings or homes in the subject area are underlain by crawl spaces then the concurrent collection air samples from these areas should also be considered. Crawl space data should be compared directly to indoor air data. As discussed above, the dilution of VOCs in crawl spaces as the air is pulled into a building is difficult to predict.

The above are initial recommendations only. Ultimate actions required at a given site should be determined on a case-by-case basis in coordination with the overseeing regulatory agency. As noted in the DTSC guidance document, indoor air data should be used to better ascertain human health concerns when potentially significant impacts are implied by soil gas and other subsurface data. The DTSC document recommends that at least two rounds of indoor data be collected prior to determining appropriate response activities. The scope of specific responses should be determined on a case-by-case basis in coordination with the overseeing regulatory agency. Active mitigation of indoor air impacts may be recommended (or even required) at sites where a need to reduce exposure of individuals is desired even though health risk objectives noted above are not exceeded.

A contingency plan based on the data to be collected should be included as part of the indoor air sampling plan.

If vapor intrusion concerns are primarily for future buildings, then remediation of VOC impacts prior to construction should be considered. If this is not feasible (e.g., impacts due to continuing offsite source) then engineered controls to mitigate vapor intrusion concerns should be incorporated into future building designs. The scope and oversight of these controls should be determined on a site-specific basis in coordination with the overseeing regulatory agency. Long-term oversight requirements are typically much more stringent for residential properties. In some cases, formal incorporation of engineered controls in building permits (e.g., under CEQA) may be warranted with long-term oversight of the controls being undertaken by the local municipal agency.

2.9 Substitution of Laboratory Reporting Limits and Ambient Background Concentrations for ESLs

In cases where an ESL for a specific chemical is less than the laboratory method reporting limit for that chemical (as agreed upon by the overseeing regulatory agency), it is generally acceptable to consider the method reporting limit in place of the screening level. Potential examples include the soil health-based ESLs for dioxin (e.g., 0.0000046 mg/kg for residential exposure).

Background concentrations of metals in soils are presented in the summary lookup tables in cases where they exceed screening levels for human health and environmental concerns. This is particularly an issue for arsenic and thallium in Bay area soils. For example, typical mean background concentrations of arsenic in Bay area soils ranges from approximately 5 mg/kg to 20 mg/kg, with some soils containing in excess of 40+ mg/kg arsenic (LBNL 2002). These concentrations are well above the health-based, direct-exposure goals for arsenic in soil of 0.066 mg/kg (residential exposure) and 0.28 mg/kg (commercial/industrial exposure) presented in the appendices. **(Note that atomic absorption laboratory methods are preferred over ICP methods for analysis of arsenic in soil.)**

For use in this document, an assumed background level of 5.5 mg/kg arsenic was substituted for toxicity-based goals in the lookup table if higher than the later. A background concentration of 58 mg/kg total chromium in soil is also assumed in the lookup tables. Note that background levels of total chromium can be significantly higher (>1,000 mg/kg) in soils developed over mafic and ultramafic rocks in the Bay area. Refer also to Appendix 1, Section 3.2.4 for additional discussion of this issue.

Figure 4 suggests steps that could be taken when evaluating a site for potential arsenic impacts. The natural background concentration of a chemical in soil or groundwater can vary significantly between and even within sites and is most appropriately evaluated by the collection of on-site samples or by reference to local data collected from past studies. Guidance for estimating background concentrations of chemicals in soil and groundwater is provided in the CalEPA document *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a). Sources of background metal concentration in soils in California include the University of California-Riverside report *Background Concentrations of Trace and Major Elements in California Soils* (UCR 1996) and the Lawrence Berkeley Laboratory document *Protocol for Determining Background Concentrations if Metals in Soil at Lawrence Berkeley National Laboratory* (LBNL 2002).

A similar approach should be taken for total chromium. Additional review of background total chromium concentrations in soil should be carried out at sites where the screening level of 58 mg/kg is exceeded. If reported levels of total chromium still appear to exceed anticipated site-specific background levels, then soil samples should be tested for Cr VI and Cr III. Data should be compared to screening levels for these specific species of chromium and action taken as needed.

2.10 Implied Land-Use Restrictions Under Tier 1

Allowing the option to tie screening levels or cleanup levels to site-specific land use and exposure conditions can save considerably in investigation and remediation costs. For example, the screening level for polychlorinated biphenyls (PCBs) in surface soils is 0.22 mg/kg in residential areas but up to 7.0 mg/kg (at target risk of 10^{-5}) for commercial/industrial areas. Even higher levels of PCBs could potentially be allowed to remain in place onsite provided that adequate controls to mitigate potential exposure are put into effect (e.g., permanent cap, protection of groundwater, etc.).

The use of final cleanup levels less stringent than those appropriate for unrestricted land use will, however, place restrictions on future use of the property. For example, if a site is remediated using ESLs (or alternative criteria) intended for commercial/industrial land use then the site cannot be used for residential purposes in the future without additional evaluation. In most cases, this will require that a formal covenant to the deed be recorded to restrict future use of the property. As stated in recent provisions in the Porter-Cologne Act (Section 13307.1(c)):

> "...if the state board or the regional board finds that the property is not suitable for unrestricted use...then the state board and regional boards may not issue a closure letter, or make a determination that no further action is required...unless a land restriction is recorded..."

The use of ESLs for deep soils at a site similarly assumes that the impacted soil will remain isolated below the ground surface "for eternity". For single-family, residential areas, future disturbance of soil situated greater than three meters is generally considered to be unlikely (CalEPA 1996a) and use of the ESLs for deep soil below this depth without restrictions may be reasonable (see Section 2.5). During the redevelopment of properties for commercial/industrial or high-density residential use, however, excavation and removal of soils from depths in excess of five or even ten meters could take place (e.g., for underground parking garages, elevator shafts, utilities, etc.). The need to impose enforceable, institutional controls for proper management of deep, impacted soils at properties where the subsurface ESLs (or alternative cleanup levels) are applied should be discussed with the overseeing regulatory agency on a site-by-site basis.

Land-use restrictions inherent in the selection of ESLs from the Tier 1 lookup tables (or assumptions used in site-specific risk assessments) should be kept as minimal as possible. **Concentrations of chemicals in impacted soils left in place at a commercial/industrial site should always be compared to both commercial/industrial AND residential ESLs (or alternative criteria for unrestricted land use).** If the soils in fact meet ESLs for unrestricted land use after cleanup then this should be clearly stated in the site closure report. Recognizing this point may prove important should the site unexpectedly become desirable for other use in the future (e.g., residential, school day care, health care, etc.). **Assumptions that impacted soil at a property will remain isolated at shallow depths under pavement, buildings or some other type of "cap" should likewise be avoided if at all possible.** Such assumptions place significant and oftentimes unnecessary restrictions on the future use and redevelopment of a site. If done, appropriate covenants to the property deed should be prepared and methods to prevent or manage future disturbance of the soil should be clearly described and ensured. A foresighted approach in the use of Tier 1 ESLs or alternative, site-specific cleanup levels will allow more flexibility in future use of a site, help avoid unexpected complications during site redevelopment and minimize the liability of future land owners.

2.11 Cumulative Risks at Sites With Multiple Chemicals of Concern

Risks posed by direct exposure to multiple chemicals with similar health affects are considered to be additive or "cumulative." For example, the total risk of cancer posed by the presence of two carcinogenic chemicals in soil is the sum of the risk posed by each individual chemical. The same is true for chemicals that cause noncarcingenic health effects. A summary of example target health effects for the chemicals listed in the lookup tables is provided in Appendix 1 (Table L).

Use of ESLs for single chemicals is limited to the extent that the screening levels remain protective of human health should other chemicals with similar health effects also be present. Soil ESLs are considered to be adequate for use at sites where no more three carcinogenic chemicals or five chemicals with similar noncarcinogenic ("systemic") health effects are present. This is based on a combination of conservative exposure assumptions and target risk factors in direct-exposure models. Refer to Appendix 1, Section 1.3, for additional discussion of this subject.

2.12 Framework For a Tier 1 Environmental Risk Assessment

Tier 1 environmental risk assessments should serve as "stand alone" documents that provide a good summary of environment impacts at a site and assess the threats posed to human health and the environment by these impacts. The risk assessment can be prepared as a component of a site investigation or remedial action report or as a separate document. Information on each of the topics listed below should be addressed in report that presents the risk assessment, however (after MADEP 1995). Together, this information is intended to provide a basic "conceptual model" of site conditions. The level of detailed required for each topic will vary depending on site-specific considerations.

1. Summarize Past, Current and Anticipated Future Site Activities and Uses:
   - Describe past and current site uses and activities;
   - Describe foreseeable future site uses and activities. **(Always include a comparison of site data to ESLs for residential/unrestricted land use to evaluate need for formal covenants to the deed; see Section 2.10).**
2. Summary of Site Investigation:
   - Identify all types of impacted media;
   - Identify all sources of chemical releases;
   - Identify all chemicals of concern;
   - Identify magnitude and extent of impacts that exceed ESLs to extent feasible and applicable (include maps of site with isoconcentration contours for soil and groundwater);
   - Identify nearby groundwater extraction wells, bodies of surface water and other potentially sensitive ecological habitats;
   - Ensure data are representative of site conditions.
3. Summarize Appropriateness of Use of Tier 1 Lookup Tables and ESLs (see Section 1.5):
   - Do Tier 1 ESLs exist for all chemicals of concern?
   - Does the site have a high public profile and warrant a fully documented, detailed environmental risk assessment?
   - Do soil and groundwater conditions at the site differ significantly from those assumed in development of the lookup tables (e.g., low pH at mine sites)?
   - Do impacts pose a heightened threat to sensitive ecological habitats (e.g., presence of endangered or protected species)?

- Have more than three carcinogens or five chemicals with similar noncarcinogenic health effects been identified (see Section 2.11)?
- Other issues as applicable to the site.

4. Soil and Groundwater Categorization (see Sections 2.4 and 2.5):

- State the regulatory beneficial use of impacted or potentially impacted groundwater beneath the site; discuss the actual, likely beneficial use of groundwater based on measured or assumed quality of the groundwater and the hydrogeologic nature of the soil or bedrock containing the groundwater.
- Characterize the soil type(s) and location of impacted soil as applicable to the lookup tables (e.g., soil stratigraphy, soil texture and permeability, depth to and thickness of impacted soil, etc.).

5. Exposure Point Concentrations (see Section 2.2, Step 7):

- Identify maximum concentrations of chemicals present in impacted media.
- Describe how alternative exposure point concentrations were determined (e.g., 95% UCLs), if proposed, and provide supporting data. **For residential land use scenarios, sample data should be averaged over no more than a $100m^2$ (1,000 ft^2) area**. **For vapor intrusion concerns, groundwater, soil and/or soil gas data should not be averaged over the floor space area of existing or anticipated buildings.**
- Discuss the need to evaluate groundwater data with respect to surface water standards for potential bioaccumulation of chemicals in aquatic organisms due to the size of the plume, the proximity of the plume to a body of surface water and the potential for minimal dilution of groundwater upon discharge to surface water (see Section 2.7).
- Discuss how background concentrations of chemicals were determined, if considered for use in the risk assessment (see Section 2.9).

6. Selection of Tier 1 ESLs and Comparison to Site Data (see Section 2.2)

- Summarize how Tier 1 ESLs were selected with respect to the information provided above and additional assumptions as applicable.
- Compare site data to the selected summary Tier 1 ESLs (presented in Volume 1) and discuss general results.
- If desired or recommended, compare site data to detailed ESLs for individual environmental concerns (presented in Volume 2, Appendix 1) and discuss specific, potential environmental concerns present at site.

7. Conclusions (see Section 2.10):

- Describe the extent of soil and groundwater impacts above Tier 1 ESLs, using maps and cross sections as necessary.
- Discuss if a condition of potential risk to human health and the environment exists at the site.
- Discuss if a more site-specific risk assessment is warranted at the site.

- Present a summary of recommended future actions proposed to address environmental concerns ay the site.
- Discuss the need to impose land-use restrictions and institutional controls at the site based on the results of the Tier 1 assessment (e.g., requirements for caps, etc.; need for covenant to deed to restrict land use to commercial/industrial purposes only, etc).

The above list is not intended to be exhaustive or representative of an exact outline required for all Tier 1 risk assessments. Requirements for completion of an adequate site investigation and Tier 1 environmental risk assessment should be discussed with the overseeing regulatory agency.

3

Tier 2 and 3 Environmental Risk Assessments

3.1 Conditions Warranting More Detailed Risk Assessments

Use of the Tier 1 Environmental Screening Levels is optional and independent environmental risk assessments may be undertaken for any site. In some cases, site conditions may negate the full use of the Tier 1 ESLs and require preparation of a Tier 2 or Tier 3 risk assessment. Examples of site conditions that may warrant a more site-specific or detailed risk assessment include (see also Section 1.5):

- Sites where alternative target risk levels or chemical-specific toxicity factors may be acceptable to the regulatory agency (see Appendix 1, Sections 1.3 and 3.2);
- Sites where the thickness of vadose-zone soils impacted by volatile organic compounds is greater than three meters (soil screening levels for potential indoor air concerns may not be adequately conservative; see Section 2.8 and Appendix 1, Section 3.3);
- Sites where screening levels for soil are driven by potential leaching concerns and groundwater data are available for evaluating actual groundwater impacts (main mass of impacted soil should be in contact with groundwater; see Appendix 1, Section 3.4);
- Sites where inorganic chemicals (e.g., metals) cannot be assumed to be immobile in soil (potential threat to groundwater quality; see Appendix 1, Section 3.4);
- Sites with soils impacted by pesticides, where final screening levels are driven by leaching concerns and potential impacts to aquatic habitats but the site is not located near a body of surface water (e.g., dieldrin, endrin, endosulfan, etc.);
- Sites where the depth to groundwater is greater than ten meters below the base of impacted soil (soil screening levels for leaching concerns may be excessively conservative; see Appendix 1, Section 3.4);

- Sites where protected terrestrial habitats or other ecologically sensitive areas are threatened (soil ESLs may not be adequately conservative; see Appendix 1, Section 3.5);

- Sites where engineered controls will be implemented to eliminate or reduce specific exposure pathways (avoid whenever possible; see Section 2.10);

- Sites where the future erosion of shallow soils could lead to significant transport and concentration of contaminants in sensitive ecological habitats; and

- Sites where field observations or site conditions otherwise indicate that the ESLs may not be adequately conservative or may be excessively conservative.

Reliance on only the Tier 1 ESLs to identify potential environmental concerns may not be appropriate for some sites. Examples include sites that require a detailed discussion of potential risks to human health; sites where physical conditions differ drastically from those assumed in development of the ESLs (e.g., mine sites, landfills, etc., with excessively high or low pH) and sites where impacts pose heightened threats to sensitive ecological habitats. The latter could include sites that are adjacent to wetlands, streams, rivers, lakes, ponds or marine shoreline or sites that otherwise contain or border areas where protected or endangered species may be present. Potential impacts to sediment are also not addressed (e.g., presence of endangered or protected species). The need for a detailed ecological risk assessment should be evaluated on a site-by-site basis for areas where these concerns may be present (see Section 3.3.5). Notification to the Natural Resource Trustee Agencies (including the state Department of Toxics Substances Control and Department of Fish and Game and the federal Fish and Wildlife Service, Department of the Interior and National Oceanic and Atmospheric Administration) may also be required, particularly if the release of a hazardous substance may impact surface waters.

Evaluation of landfills and sites impacted by mine wastes may in particular require the preparation of a detailed, site-specific assessment of groundwater and surface water impact concerns due to the possible elevated mobility of metals and other chemicals and potential explosive gases concerns (e.g., methane). Soil leaching models incorporated into the Tier 1 ESLs assume typical, ambient physio-chemical conditions in soil and groundwater (e.g., soil pH 5.0 to 9.0) and the relatively immobility of heavy metals and organic chemicals with very high sorption factors (e.g., PCBs, PAHs, stc.). This assumption may not hold true at many landfill and mine sites, where extreme pH and Eh conditions could lead to substantial mobility of these compounds. In these and other related cases, more rigorous field and laboratory studies may be required to adequately assess risk to human health and the environment.

Final surface water and groundwater screening levels for several pesticides that are highly toxic to aquatic organisms are very stringent (e.g., dieldrin, endrin, endosulfan, etc.; refer to Tables A-D in this volume and Table F series in Appendix 1). Correlative soil screening levels for leaching concerns are likewise very stringent (refer to Table A-D series in Appendix 1). The pesticides in question are only moderately mobile in the environment. The final soil and groundwater screening levels are likely to be excessively conservative for sites not located near a body of surface water. The need to apply the screening levels to soil and groundwater data should be evaluated on a site-by-site basis. Less conservative screening levels for evaluation of human-toxicity concerns only may be appropriate at many sites.

Site-specific risk assessments are grouped under the loosely defined terms "Tier 2" and "Tier 3". The nature of these risk assessments is briefly discussed below.

3.2 Tier 2 Environmental Risk Assessments

3.2.1 Purpose

Tier 2 environmental risk assessments are intended to be relatively easy and cost-effective to prepare. Preparation of Tier 2 risk assessments will require a thorough understanding of the Tier 1 ESLs being re-evaluated, however. Under Tier 2, specific Tier 1 screening levels are adjusted or deleted to more closely reflect site conditions or alternative risk assumptions. Replacing only targeted components of the Tier 1 ESLs reduces the need to prepare and justify an independent, detailed risk assessment when Tier 1 ESLs cannot or should not be fully applied. This greatly reduces the time and cost incurred by both the regulated business and the overseeing regulatory agency in finalizing the risk assessment.

For example, the Tier 1 screening level for leaching concerns may not need to be considered at sites where groundwater monitoring data indicate that leaching impacts from soil to groundwater are minimal or not posing an adverse risk. A common modification under Tier 2 may also include the adjustment of target risk level for carcinogens in soils at commercial/industrial sites from 10^{-6} to a cumulative risk of 10^{-5} or a cumulative hazard index of 1.0 (and likely preparation of a covenant to the deed that formally restricts land use). This could increase the direct-exposure screening levels for carcinogens by a factor of up to ten. In these examples, all other components of the Tier 1 ESLs are retained for use in the risk assessment. The modifications to Tier 1 assumptions are described and justified in the text of the report and the revised set of screening levels are presented.

3.2.2 Example Tier 2 Modifications of Tier 1 ESLs

A more detailed list of potential Tier 2 modifications to Tier 1 screening levels is presented below (refer also to Appendix 1). These examples are not intended to reflect the full range of modifications possible:

Groundwater Screening Levels

Drinking Water:

- Exclusion of drinking water impact concerns based on natural groundwater quality or geologic characteristics of groundwater containing unit (e.g., brackish groundwater in coastal areas);

Vapor Intrusion:

- Use of site-specific data for model input parameters (depth to groundwater, soil properties, building characteristics, target risk or hazard index, etc.);
- Use of soil gas and/or indoor air data to more directly evaluate potential impacts;
- Use of alternative chemical toxicity factors or target risk levels;

Surface Water Impacts:

- Exclusive use of freshwater or saltwater screening levels;
- Consideration of alternative surface water screening levels;
- Consideration of groundwater monitoring data and observed plume migration over time;
- Consideration of site-specific dilution effects during potential discharge of groundwater to surface water (generally not recommended except in highly developed and disturbed water front properties);

Gross Contamination:

- Use of alternative ceiling levels and/or site-specific observations and considerations regarding gross contamination concerns;

General:

- Consideration of method reporting limits or natural background concentrations of a chemical in place of the ESL.

Soil Screening Levels

Direct Exposure:

- Use of alternative chemical toxicity factors or target risk levels;

- Use of alternative screening level for lead at sites where backyard gardens or other exposure scenarios considered in ESLs are not anticipated (refer to Appendix 1, Section 3.2.3);
- Elimination of direct-exposure concerns through imposition of institutional controls;
- Exclusion of direct-exposure concerns due to depth of impacted soil below ground surface (e.g., >10 meters bgs).

Vapor Intrusion:

- Use of soil gas and/or indoor air data to more directly evaluate potential impacts (generally recommended);
- Use of alternative chemical toxicity factors or target risk levels.

Groundwater Protection (leaching effects):

- Consideration of alternative, target groundwater levels;
- Use of groundwater monitoring data to evaluate leaching impacts and groundwater quality concerns (most appropriate where main mass of chemical is in contact with groundwater);
- Use of laboratory leaching test to evaluate potential groundwater impacts (see Section 3.3.3).

Ecological Impact Concerns:

- Use of alternative screening levels based on site studies or published data;
- Reconsideration of need to include eco-based screening levels in highly developed or industrialized areas.

Gross Contamination:

- Use of alternative ceiling levels and/or site-specific observations and considerations for gross contamination concerns.

Soil Gas Screening Levels

- Use of indoor air data to more directly evaluate potential health risk concerns;

- Use of soil gas data to calibrate mass-balanced evaluation of potential vapor intrusion impacts.

General:

- Consideration of method reporting limits or natural background concentrations of a chemical in place of the ESL.

In each of these examples, an alternative screening level is generated for the specified environmental concern and re-compared to site data. Models and assumptions used to generate each of the Tier 1 screening levels are discussed in detail in Appendix 1. The format of the Tier 2 Environmental Risk Assessment Report should be similar to that outlined for Tier 1 reports. Adjustments to Tier 1 screening levels should be clearly described and justified within the report and additional information included as necessary.

It is beyond the current scope of this document to provide detailed examples of potential Tier 2 assessments. A discussion of mass-balance issues and soil gas data is presented below, however, given the current emphasis on the vapor intrusion exposure pathway.

3.2.3 Mass-Balanced Evaluation of Soil Gas Data

As discussed earlier (Section 2.8.2), it is not uncommon to identify relatively high levels of PCE in soil gas beneath the floors of dry cleaners even though soil data suggest that very little PCE is actually present. This could be due to the presence of relatively dry fill material with very little organic carbon under the buildings. In contrast to more "normal" soils with higher moisture contents and organic carbon, most of the PCE in this type of fill material will be in the vapor phase (see Section 2.8.2)

Relatively simple models for the partitioning of chemicals in soil shed some light on this observation (e.g., USEPA 1996). For example, in the default soil type used in the ESL models (15% soil moisture, 0.6% organic carbon; refer to Appendix 1), the majority of PCE will be sorbed to soil particles (75%) with a lesser amount in vapor phase (15%) and the remainder dissolved in the soil moisture (10%). In dryer soils (e.g., 5% soil moisture) with a very low organic carbon content (e.g., 0.01%), the proportion of PCE in the vapor phase increases to 80%.

Use of soil gas data alone in the latter example may suggest unacceptable long-term impacts to indoor air. Common sense suggests that the problem is not as severe as the soil gas data suggest, however. This is because the actual mass of VOCs present is not taken into account in the vapor-intrusion model used to develop the soil gas screening levels (refer to Appendix 1). At the theoretical vapor emission rate calculated in the models (e.g., grams of VOC emitted per second per unit area), sites where only a limited mass of a VOC is present would "run out" of VOCs well before the exposure duration being considered was reached (typically 30 years). For an evaluation of average, long-term impacts to indoor air, it is more appropriate to consider the total mass of VOCs present and calculate a more realistic, "mass-balanced" long-term vapor emission rate.

At sites where the main mass of VOC is present in vapor phase, a more site-specific, "mass-balanced" estimation of potential long-term impacts to indoor air may be appropriate. A mass-balanced vapor emission rate is calculated as the total mass of a given VOC present per unit area (e.g., 100 grams of PCE beneath each square meter of impacted soil) divided by the exposure duration of concern (e.g., 30 years for residences and 25 years for commercial/industrial sites). This cannot be done using USEPA's soil gas vapor intrusion spreadsheet but it can be done using the soil vapor intrusion model (refer to Appendix 1). The average, total concentration of a given VOC in soil can be estimated from soil gas data using a relatively simple equilibrium partitioning equation and site data for soil moisture and total organic carbon content (refer to USEPA 1996; calculate dissolved-phase concentration based on vapor phase/soil gas data and solve equation for total soil concentration). The estimated value can be compared to soil sample data collected at the site for field verification.

The estimated total concentration of the VOC in soil can then be input into the USEPA vapor intrusion spreadsheet for soils along with the area and depth of impacted soil. The model will then calculate both a theoretical vapor emission rate, based on the VOC being modeled and the soil type, and a mass-balanced vapor emission rate based purely on the total mass of the VOC present (concentration x soil density x volume impacted soil) and the input exposure duration. If lower than the theoretical emission rate, the spreadsheet will select the mass-balanced emission rate to calculate an average, long-term vapor emission rate and subsequent risks to human health due to impacts to indoor air (refer to INTERCALC page of worksheet, "Exposure Duration > time for source depletion" term). **If a mass-balanced approach is used to evaluate vapor intrusion concerns, however, the acceptability of potential short-term impacts to indoor air must also be evaluated** (e.g., refer to Section 2.8.2 and CalEPA 2004b).

The "infinite-source" models used to calculate direct-exposure ESLs for VOCs also pose potential mass-balance issues for sites with limited volumes of contaminated soil. This is briefly discussed in Section 3.3.

3.3 Tier 3 Environmental Risk Assessments

3.3.1 Purpose

Under Tier 3, alternative models and assumptions are used and fully justified to develop a detailed, comprehensive environmental risk assessment. Portions of the Tier 1 models may still be retained for some components of the risk assessment. A detailed review of the preparation of Tier 3 environmental risk assessments is beyond the scope of this document. A few potentially useful methods and some general cautions are highlighted below. Example references for the preparation of Tier 3 risk assessments are provided at the end of this section.

3.3.2 Mass-Balanced Soil Volatilization Factor Model

A good example of a useful, alternative model for evaluating soil direct-exposure concerns is the mass-balanced volatilization factor model provided in the USEPA document *Soil Screening Guidance* (USEPA 1996) and used in the City of Oakland RBCA program (Oakland 2000). This model was used in earlier versions of the USEPA Preliminary Remedial Goals (PRGs) document (pre-1995). The current PRG model, and the model reflected in the soil direct-exposure screening levels presented in this document, assumes an infinite thickness of contaminated soil at a site. For highly volatile chemicals such as vinyl chloride and even benzene, this is excessively conservative and would require the presence of tens of meters impacted soil over a large area to be justifiable. The mass-balanced model allows for the input of the actual thickness of impacted soil at a site and can result in substantially less stringent, and more realistic, screening or cleanup levels for direct-exposure concerns. Note, however, that groundwater protection concerns (i.e., soil leaching) or potential indoor-air impacts often drive screening level environmental concerns at sites impacted with highly mobile, volatile chemicals. This concern and others, as appropriate, should be evaluated in conjunction with direct-exposure concerns.

Easy-to-use spreadsheets that incorporate the mass-balanced direct-exposure model are available for downloading from the Hawaii Department of Health website (HIDOH 1995, 2005; DETIER2 spreadsheet developed by editor of this document) as well as the City of Oakland website (Oakland 2000), among other sources. Care should be taken to ensure that default toxicity factors presented in these and other spreadsheets are consistent with those used in California (see Appendix 1, Table J). In the future, a similar spreadsheet may be directly available from the RWQCB (refer to contacts listed at front of document).

3.3.3 Laboratory-Based Soil Leaching Tests

Laboratory-based soil leaching tests offer an alternative to the use of conservative, model-derived soil screening levels for groundwater protection concerns (refer to Section 3.4 in Appendix 1). These tests may be especially useful for evaluating soils impacted by inorganic chemicals (e.g., metals and salts) and relatively nonsorptive and nonvolatile organic chemicals. Screening levels for leaching of metals from soil are specifically excluded from this document. Where releases of metal compounds to soil are identified, groundwater monitoring (if appropriate) and/or laboratory-based leaching tests should be carried out to fully evaluate potential leaching impacts (refer to Section 3.4 of Appendix 1).

The USEPA Synthetic Precipitation Leaching Procedure (SPLP) is one example of laboratory-based soil leaching tests (USEPA 1994). The SPLP test differs from the more commonly referenced Toxicity Characteristic Leaching Procedure (TCLP) for hazardous waste in that it is specifically designed to evaluate the mobility of organic and inorganic compounds in soils. The results of an SPLP test are compared to regulatory levels for disposal of materials in landfills and this is then used to determine the type of landfill most appropriate for disposal of the soil (e.g., lining, leachate collection system requirements, etc.).

The SPLP test was **not** specifically developed to evaluate leaching of chemicals from soil outside of a controlled, landfill environment but can be used to do so with some caveats. From a groundwater protection standpoint, one goal is to predict the dissolved-phase concentration of a chemical in the pore space of a saturated soil sample (i.e. the leachate) through either models or laboratory tests. The SPLP test does **not** directly provide this information. Using the SPLP test method, 100 grams of soil are added to two liters of reagent water, the sample is mixed for a specified period of time, and an extract of the regent water is analyzed for targeted chemicals. The volume of reagent water added to the sample significantly exceeds the volume of the sample pore space. This leads to significant dilution of the potential "leachate" had the volume of added reagent water only been equal to the volume of the sample pore space.

For example, the pore volume of a 100-gram sample of soil with 35% effective porosity is approximately 20 cm^3 (assumes bulk density of 1.8, total volume 57 cm^3). Adding two liters, or 2,000 cm^3, of water to the sample therefore introduces a laboratory-based, leachate "dilution factor" of approximately 100 to the SPLP test results (volume reagent divided by volume sample pore space). Concentrations of chemicals reported under the SPLP test could therefore be up to 100 times less than the dissolved-phase concentration of the chemical in a saturated sample.

The inherent dilution effect of the SPLP test method is only significant for chemicals that are highly mobile and not significantly volatile (or biodegradable). From a fate and transport perspective, the dilution factor inherent in the SPLP test could be considered to reflect the decrease in chemical concentrations due to resorption, volatilization and dilution as the leachate migrates downward and mixes with groundwater. Based on comparisons of soil leaching models that take these fate and transport considerations into account (e.g., SESOIL, see Appendix 1) and those that don't (e.g., USEPA 1996), the dilution factor inherent in the SPLP test method appears to be adequately conservative for chemicals that are at least moderately sorptive (i.e., sorption coefficient of at least 100 cm^3/g) or highly volatile (i.e., Henry's Constant of at least 0.001 atm-m3/mole.). **For moderately sorptive and/or volatile chemicals, the results of the SPLP test can be**

directly compared to target groundwater goals. This includes most of the organic chemicals listed in the ESL lookup tables (refer to Table J in Appendix 1).

Chemicals listed in the ESL document that are not adequately sorptive or volatile to justify unmodified use of the SPLP test method include all inorganic compounds (e.g., metals and perchlorate) as well as acetone, 2,4 dinitrophenol and methyl ethyl ketone (very low sorption coefficients). Other organic chemicals that fail this test but only moderately include bis(2-chloroethyl)ether, bis(2-chloroisopropyl)ether, chloraniline, 1,2 dibromoethane, 2,4 dimethylphenol, 2,4 dinitrotoluene, MTBE, phenol, 1,1,1,2-tetrachloroethane and 1,1,2,2-tetrachloroethane. **For these and other relatively nonsorptive and nonvolatile chemicals not listed in the ESL tables, the results of the SPLP test should be multiplied by a factor of 100 (or a sample-specific factor) to negate the method-related dilution effect.** The sample results can then be adjusted with respect to chemical-specific and site-specific Dilution/Attenuation Factors (DAFs) that take into account volatilization, resorption, degradation and other factors anticipated to reduce the concentrations of chemicals in leachate as the leachate migrates downward and ultimately mixes with groundwater.

Relatively simple DAFs that only address mixing of leachate with groundwater can be calculated using equations provided in the USEPA *Soil Screening Guidance* (USEPA 1996), among other sources. For the Bay area, simple leachate/groundwater mixing DAFs for shallow aquifers would typically fall in the range of 5 for silty soils to 20 for sandy soils (e.g., assuming 2m thick shallow aquifer, 30% effective porosity, infiltration rate of 8.0 cm/year (3 inches/year or approximately 15% of total, average rainfall), and hydraulic conductivities of 2m/day and 15m/day, respectively). DAFs could be much higher for areas with fast moving groundwater and/or little infiltration of precipitation and lower in areas with slow moving groundwater and/or greater infiltration of precipitation. Potentially less conservative DAFs that also address resorption, volatilization and other factors can be calculated using more rigorous models such as SESOIL (see Appendix 1).

3.3.4 Tier 3 Environmental Risk Assessments for Parklands

For initial cleanup efforts at sites to be used as parks or wildlife refuges, it is strongly recommended that such areas be remediated to meet unrestricted land use (i.e., assumed residential exposure, target Excess Cancer Risk of one-in-a-million; target Hazard Index of 1.0 and address potential ecological concerns). From a strictly toxicological standpoint, a typical recreational-use exposure scenario may suggest that substantially higher concentrations of contaminants could be left in place at the site and not pose a threat to human health. Public parks are typically frequented by children, young mothers, elderly people and other groups of people with potentially elevated sensitivities to environmental contaminants, however. In addition, cleanup levels based on recreational land-use scenarios are oftentimes higher (less stringent) than levels that would be allowed for commercial/industrial properties. This intuitively goes against the concept of developing a park as "refuge" for humans and wildlife. Assumption of a limited exposure frequency and duration (e.g., 100 days per year for ten years) also puts an inherent restriction on the number of days and years that an individual can visit the park without exceeding potential health hazards. Long-term, future uses of such properties are also difficult to predict.

In some cases, remediation of proposed parklands to unrestricted land-use standards may not technically or economically feasible. This should be evaluated on a site-specific basis and receive approval from the overseeing regulatory agency. In such cases, the appropriateness of allowing unrestricted access to the area should be carefully evaluated. This could include the need to impose access restrictions on the property (i.e., based on the exposure assumptions used in the risk assessment) and/or cap impacted soils with a minimal amount of clean fill. It may also be prudent to post signs at the property entrance that warn of potential health hazards (see Section 2.10).

3.3.5 Tier 3 Reference Documents

Potentially useful reference documents for preparation of Tier 3 environmental risk assessments include the following:

Human Health Risk Assessment:

- *Superfund Exposure Assessment Manual* (USEPA 1988)
- *Risk Assessment Guidance for Superfund. Volume I, Human Health Evaluation Manual* (Part A) (USEPA 1989a);
- *Soil Screening Guidance: Technical Background Document* (USEPA 1996);
- *CalTOX, A Multimedia Total Exposure Model For Hazardous-Waste Sites* (CalEPA 1994a);
- *Preliminary Endangerment Assessment Guidance Manual* (CalEPA 1994b);
- *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a);
- *Exposure Factors Handbook* (USEPA 1997a);
- St*andard Provisional Guide for Risk-Based Corrective Action* (ASTM 1995); and
- Assessing the Significance of Subsurface Contaminant Vapor Migration to Enclosed Spaces (Johnson et. al, 1998, Johnson 2002).

Ecological Risk Assessment:

- *Risk Assessment Guidance for Superfund: Volume II Environmental Evaluation Manual* (USEPA 1989b);

- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (USEPA 1997b), and

- *Guidance for Ecological Risk Assessments at Hazardous Waste Sites and Permitted Facilities* (CalEPA 1996a,b).

The above list of references is not intended to be comprehensive. Additional risk assessment guidance should be referred to as needed.

4

References

ASTM, 1995, *Standard Provisional Guide for Risk-Based Corrective Action*: American Society for Testing and Materials, Designation E2081-00.

CalEPA, 1994a, *CalTOX, A Multimedia Total Exposure Model For Hazardous-Waste Sites*: California Environmental Protection Agency, Department of Toxics Substances Control, Version 1.5 (and updates), www.cwo.com/~herd1/ caltox.htm.

CalEPA, 1994b, *Preliminary Endangerment Assessment Guidance Manual*: California Environmental Protection Agency, Department of Toxics Substances Control, January, 1994.

CalEPA, 1996a, *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities*: California Environmental Protection Agency, Department of Toxics Substances Control, August, 1996, www.dtsc.ca.gov/ScienceTechnology/index.html.

CalEPA, 1996b, *Guidance for Ecological Risk Assessments at Hazardous Waste Sites and Permitted Facilities (Parts A and B)*: California Environmental Protection Agency, Department of Toxics Substances Control, July 4, 1996, www.dtsc.ca.gov/ScienceTechnology/index.html.

CAlEPA, 2001, *Chlorinated Chemicals in Your Home* (May 2001): California Environmental Protection Agency, Air Resources Board, www.arb.ca.gov/research/indoor/clguide.pdf.

CalEPA, 2002, Response Actions For Sites Where Future Uses May Include Sensitive Uses: California Environmental Protection Agency Department of Toxic Substances Control, Site Mitigation and Brownfields Reuse Program, Management Memo EO-02-002-MM (July 0, 2002).

CalEPA, 2003, *Soil Gas Advisory* (January 2003): Department of Toxic Substances Control and Los Angeles Regional Water Quality Control Board; http://www.dtsc.ca.gov/PolicyAndProcedures/SiteCleanup/SMBR_ADV_activesoilgasinvst.pdf.

CalEPA, 2004a, *Human-Health-Based Screening Numbers Developed to Aid Estimation of Cleanup Costs for Contaminated Soil* (November 2004, updated January

2005): California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, http://www.oehha.org/risk/Sb32soils05.html.

CalEPA, 2004b, *Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air* (December 15, 2004, updated January 2005): California Environmental Protection Agency, Department of Toxics Substances Control, http://www.dtsc.ca.gov/.

CalEPA, 2004c, Annual Toxics Summaries, California Environmental Protection Agency, Air Resources Board, www.arb.ca.gov/aqd/toxics/sitesubstance.html.

CalEPA, 2005, *Use of California Human Health Screening Levels in Evaluation of Contaminated Properties* (January 2005): California Environmental Protection Agency, Department of Toxics Substances Control.

CLRRA, 2002, *California Land Restoration and Reuse Act*, California Health and Safety Code, Section 25401 *et seq*. and section 57008 *et seq*., http://www.leginfo.ca.gov/calaw.html.

Fetter, C. W., 1994, *Applied Hydrogeology*: Macmillan College Publishing Company, New York, ISBN 0-02-336490-4.

HIDOH, 1995, *Risk-Based Corrective Action and Decision Making at Sites With Contaminated Soil and Groundwater*: State of Hawai'i, Department of Health, December, 1995 (revised June, 1996), www.state.hi.us/doh/eh/shwb/ust/ index.html

HIDOH, 2005, *Screening For Environmental Concerns at Sites With Contaminated Soil and Groundwater* (January 2005, 3rd edition): Hawai'i Department of Health, Honolulu, www.state.hi.us/doh/eh/shwb/ust/ index.html.

Johnson, P.C., Kemblowski, M. W., and Johnson, R.L., 1998, *Assessing the Significance of Subsurface Contaminant Vapor Migration to Enclosed Spaces*: American Petroleum Institute, Health and Environmental Sciences Department, December, 1998, API Publication No. 4674.

Johnson, P. C. 2002. Identification of Critical Parameters for the Johnson and Ettinger(1991) Vapor Intrusion Model. API Bulletin No. 17. American Petroleum Institute.Washington, DC. May 2002, www.api,org/bulletins.

LBNL, 2002, *Analysis of Background Distributions of Metals in the Soil at Lawrence Berkeley National Laboratory*: University of California (Berkeley), Lawrence Berkeley Laboratory, June 2002.

MADEP, 1995, *Guidance For Disposal Site Risk Characterization*: Massachusetts Department of Environmental Protection, Bureau of Waste Site Cleanup and Office of Research and Standards, July 1995.

MADEP, 2002, *Indoor Air Sampling And Evaluation Guide*: Massachusetts Department of Environmental Protection, Office of Research and Standards, WSC Policy #02-430; http://www.state.ma.us/dep/bwsc/finalpol.htm;

NEIWPCC, 2003, A Hot Dog by Any Other Name Could Be You Drinking Water: New England Interstate Water Pollution Control Commission Leaking Underground Storage Tank Bulletin No. 44, pg 1-7, http://www.neiwpcc.org/.

Oakland, 2000, *Oakland Risk-Based Corrective Action: Technical Background Document: City of Oakland, Environmental Services Division*, (prepared by L.R. Spence. Spence Environmental Engineering and M. Gomez, City of Oakland), January, 2000 (and updates), www.oaklanddpw.com/urlprogram.

NIOSH, 2003, NIOSH Pocket Guide To Chemical Hazards: National Institute for Occupational Safety and Health (NIOSH), www.cdc.gov/niosh/npg/npg.html.

RWQCBSF, 1995, *Water Quality Control Plan*: California Environmental Protection Agency, Regional Water Quality Control Board, San Francisco Bay Area Region, June, 1995.

RWQCBSF, 1996, *Supplemental Instructions to State Water Board December 8, 1995, Interim Guidance on Required Cleanup at Low-Risk Fuel Sites*: California Environmental Protection Agency, Regional Water Quality Control Board, San Francisco Bay Area Region, January 5, 1996.

RWQCBSF, 2001a, *Application of Risk-Based Screening Levels (RBSLs) And Decision Making to Sites With Impacted Soil and Groundwater* (December 2001); California Environmental Protection Agency, Regional Water Quality Control Board, San Francisco Bay Area Region.

RWQCBSF, 2001b, Use of City of Oakland *Urban Land Redevelopment Program Guidance Document* and Environmental Screening Levels (letter and internal memo): California Environmental Protection Agency, Regional Water Quality Control Board, San Francisco Bay Area Region, August 3, 2001, www.swrcb.ca.gov/~rwqcb2/ESL.htm (RWQCBSF ESL web page).

SWRCB, 2000, *Guidelines for Investigation and Cleanup of MTBE and Other Ether-Based Oxygenates* (DRAFT): State Water Resources Control Board, Division of Clean Water Programs, March 30, 2000.

UCR, 1996, *Background Concentrations of Trace and Major Elements in California Soils*: University of California (Riverside), Division of Agriculture and Natural Resources, March 1996.

USEPA, 1988, *Superfund Exposure Assessment Manual*: U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Publication EPA/540/1-88/001.

USEPA, 1989a, *Risk Assessment Guidance for Superfund. Volume I, Human Health Evaluation Manual (Part A)*: U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Publication EPA/540/1-89/092.

USEPA, 1989b, *Risk Assessment Guidance for Superfund. Volume II, Environmental Evaluation Manual*: U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Publication EPA/540/1-89/001.

USEPA, 1994, Synthetic Precipitation Leaching Procedure: U.S. Environmental Protection Agency, Office of Solid Waste, SW-846 Method 1312, September 1994, www.epa.gov/epaoswer/hazwaste/test/main.htm.

USEPA, 1996, *Soil Screening Guidance: Technical Background Document*: U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Publication 9355.4-17A, May 1996.

USEPA, 1997a, *Exposure Factors Handbook*: U.S. Environmental Protection Agency, Office of Research and Development, Publication EPA/600/P-95/002Fa, August 1997.

USEPA, 1997b, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*. U.S. Environmental Protection Agency, Environmental Response Team, Interim Final. June 5, 1997, EPA 540-R-97-006.

USEPA, 2002, *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites.* U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, December 2002, OSWER 9285.6-10.

USEPA, 2003, *User's Guide For Subsurface Vapor Intrusion Into Buildings*: U.S. Environmental Protection Agency Office of Emergency and Remedial Response, March 2003, www.epa.gov/oerrpage/superfund/.

USEPA, 2004, *Preliminary Remediation Goals*: U.S. Environmental Protection Agency, Region IX, October 2002, www.epa.gov/region09/waste/sfund/prg/index.htm.

FIGURES

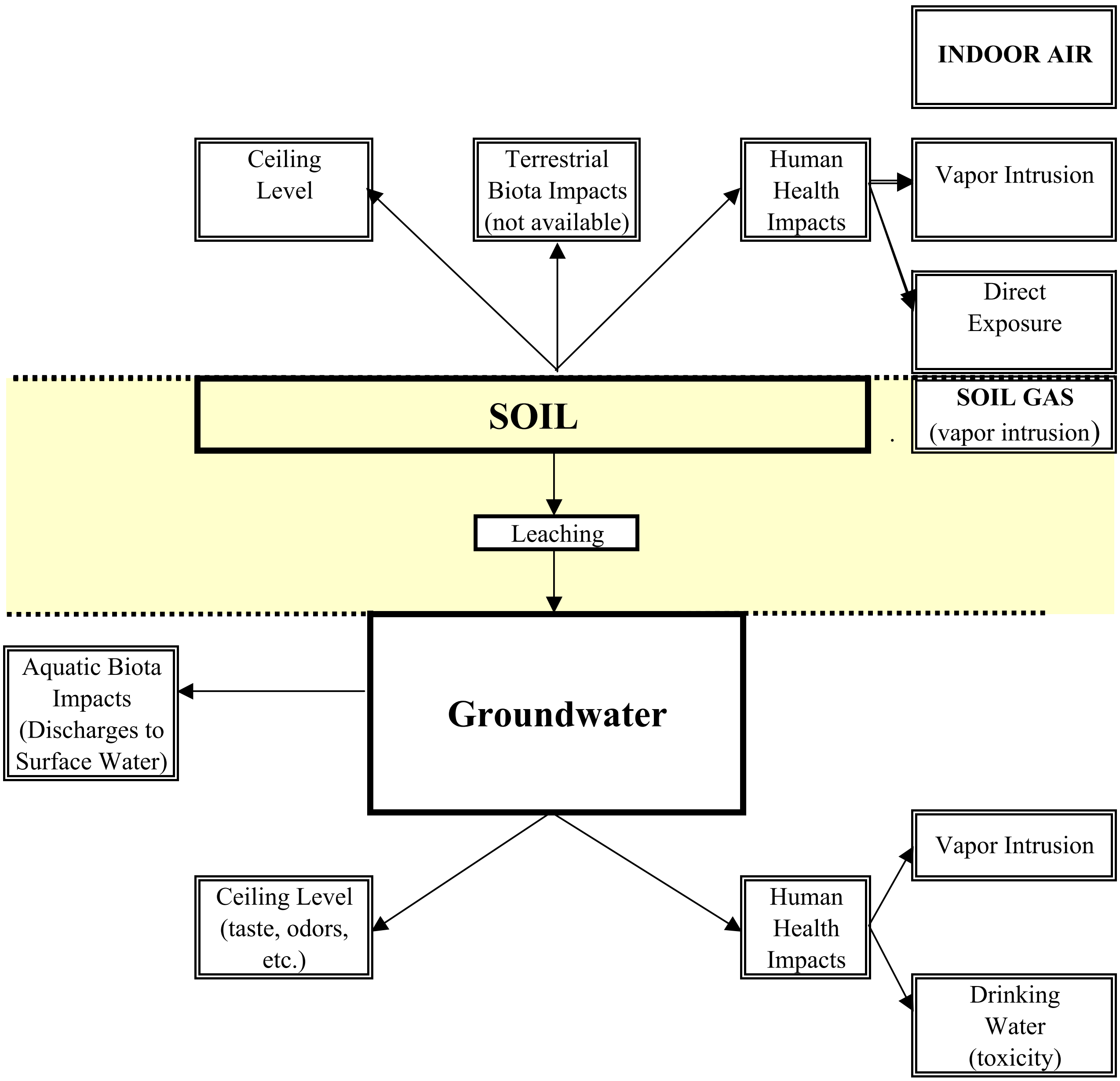

Figure 1. Summary of human health and environmental concerns considered in screening levels. Additional site-specific considerations include groundwater beneficial use, depth to impacted soil, soil type and land use. This figure is intended for Tier 1 and Tier 2 assessments only. Evaluation of environmental concerns not shown requires site-specific assessment.

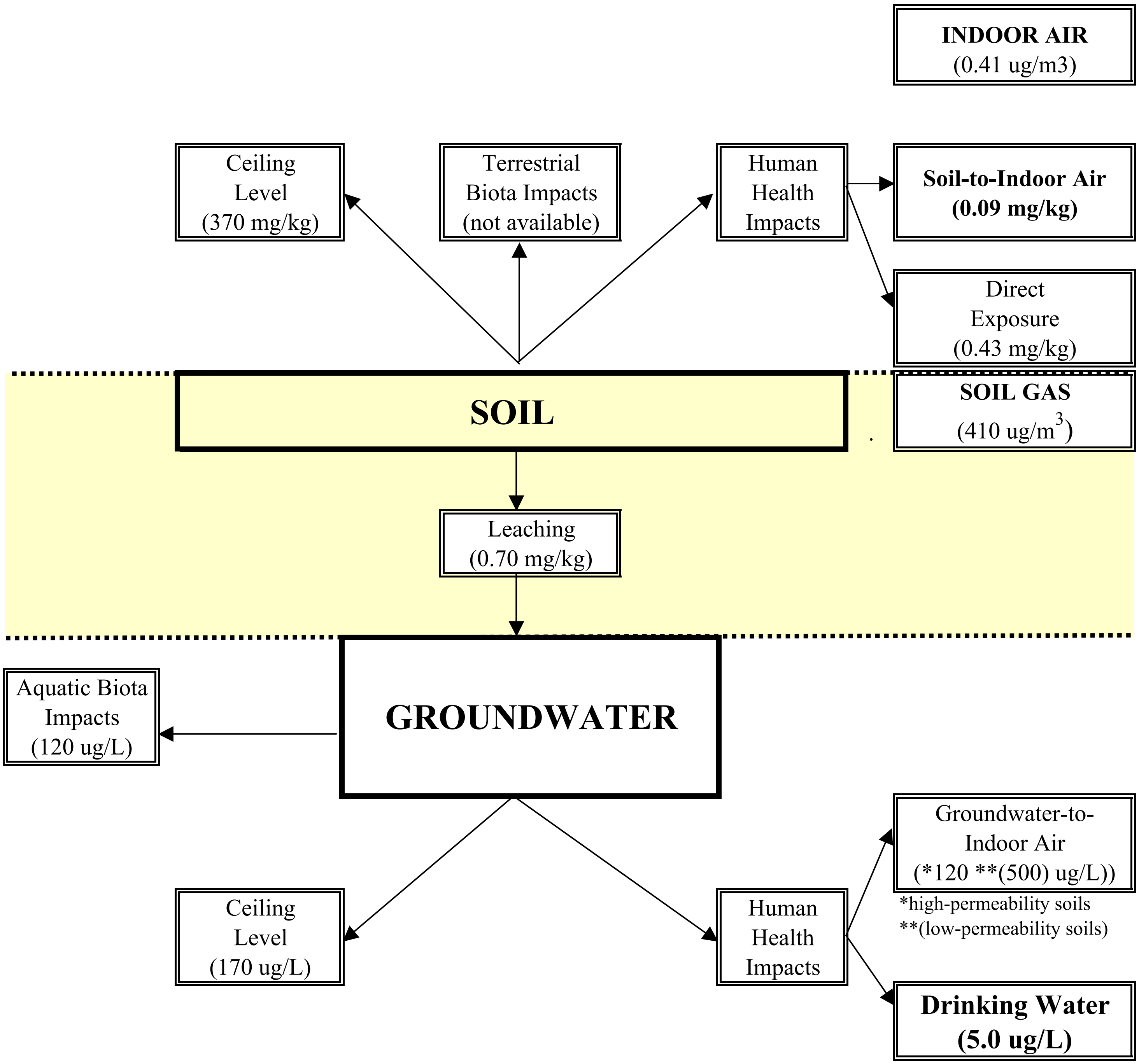

Figure 2. Summary of individual screening levels used to select final, Tier 1 ESLs for tetrachloroethylene in soils situated within ten feet of the ground surface and in groundwater that is a current or potential source of drinking water, based on a residential land-use scenario. Final ESLs presented in Volume 1 summary tables are the lowest of the individual screening levels. Potential impact to indoor air drives selection of the final soil ESL (0.09 mg/kg). For groundwater, drinking water toxicity concerns drive selection of final ESL (5.0 ug/L). Groundwater-to-indoor air screening levels for low-permeability soils not shown in summary lookup tables (refer to Table E-1a).

STEP 1: Check with the overseeing regulatory agency to ensure that the version of the lookup tables you have is up-to-date and that the screening levels can be applied to your site (see Section 1.5).

STEP 2: Select chemicals of potential concern for site based on knowledge of past site use and/or analytical data for soil or groundwater samples collected at the site.

STEP 3: Choose appropriate lookup table based on location of impacted soil and beneficial use of impacted or potentially impacted groundwater at the subject site, as summarized below:

[1]BENEFICIAL USE OF THREATENED GROUNDWATER	[2]LOCATION OF IMPACTED SOIL	
	Shallow Soils (≤ 3m bgs)	**[3]Deep Soils (> 3m bgs)**
Current or Potential Source of Drinking Water	TABLE A	TABLE C
NOT a Current or Potential Source of Drinking Water	TABLE B	TABLE D

bgs: below ground surface

1. Shallow-most saturated zone beneath the subject site and deeper zones as appropriate.
2. Depth to top of impacted soil from ground surface (3 meters = 10 feet).
3. Application of deep soil ESLs to soils <3m deep may require institutional controls (see text).

STEP 4: Go to selected lookup table. Determine desired or anticipated future use of property - "Residential Land Use Permitted" (recommended for initial use at all sites to avoid potential deed restrictions) vs "Commercial/Industrial Land Use Only".

STEP 5: Select soil ESLs for chemicals of concern from appropriate land-use column in table and/or select correlative groundwater ESLs.

STEP 6: Replace ESLs with approved laboratory method detection limit if detection limit is greater than the ESL. Replace ESLs with natural background concentration of chemical if background is higher (see text and notes at end of tables).

STEP 7: Determine vertical and lateral extent of soil and/or groundwater impacted above screening levels to extent required by overseeing agency AND/OR use selected ESLs as guide for re-use of excavated, impacted soil.

STEP 8: Evaluate additional corrective actions needed at site based on results of Step 7. (e.g., cleanup to Tier 1 ESLs, track and monitor defined groundwater plume, develop alternative screening levels in a site-specific, Tier 2 or Tier 3 environmental risk assessment, etc.). Determine specific environmental concerns for site as needed using screening levels presented in Appendix 1.

STEP 9: Submit Tier 1 Environmental Risk Assessment and work plans for additional corrective actions, as necessary, to overseeing regulatory agency.

Figure 3. Steps to selection and use of Environmental Screening Levels in Tier 1 Lookup Tables (see Section 2.2).

Figure 4. Evaluation of arsenic concentrations in soil.

[1]Concentration of Arsenic in Surface Soil	[2]Basis	Residential Land Use	Commercial/Industrial Land Use	[3]Ecological Concerns
≤5.5 mg/kg	[4]Typical average concentration of As in Bay Area soils.	No action required.	No action required.	No action required.
>5.5 mg/kg	Potentially above background for Bay Area soils. Background could range up to 20+ mg/kg in some areas.	Further evaluation of site background concentrations required (sample data, data from nearby areas, etc.). Residential land use probably not permitted without remediation to background levels. Evaluate potential impacts to groundwater as necessary.	Further evaluation of site background concentrations required (sample data, data from nearby areas, etc.). Risk management measures needed may be needed to address potential dust impacts to nearby residential areas. Evaluate potential impacts to groundwater as necessary.	Further evaluation of potential site background concentrations required (sample data, data for nearby areas, etc.). Ecological risk assessment may be needed for areas where sensitive habitats are threatened, including potential discharge of impacted groundwater to a surface water habitat.
≥28 mg/kg	Commercial/ Industrial direct-contact screening level adjusted to target risk of 10^{-4} (see Table K-2)	Same as above.	Soil remediation and/or risk management measures needed. May include need to provide clean, subsurface utility corridors for future redevelopment. Evaluate potential impacts to groundwater as necessary.	Same as above.
≥40 mg/kg	Ecological screening level for Commercial/ Industrial sites (see Table A-2)	Same as above.	Same as above.	Ecological risk assessment needed for sites where sensitive habitats are threatened.

For general reference only. More stringent criteria may be applied on a site-specific basis.

1. Shallow soils defined as soils within 3m (10ft) of ground surface.
2. Refer to noted text or table in document.
3. An ecological risk assessment may be required at lower soil concentrations than indicated for sites within or adjacent to sensitive habitats (e.g., adjacent to sensitive wetlands, endangered species threatened, etc.).
4. Arithmetic mean arsenic concentration calculated for all soils at Lawrence Berkeley Laboratory facility (LBNL 2002). Highest reported concentration of arsenic in soils at LBNL facility is 42 mg/kg.

TABLES

TABLE A: SHALLOW SOIL ($\leq$3M BGS) - WATER <u>IS</u> A CURRENT OR POTENTIAL SOURCE OF DRINKING WATER

Notes:

- Always compare final soil data for commercial/industrial sites to residential ESLs and evaluate need for formal land-use restrictions (see Section 2.10).

TABLE A. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Shallow Soil [2]Residential Land Use (mg/kg)	[1]Shallow Soil Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
ACENAPHTHENE	1.6E+01	1.6E+01	2.0E+01
ACENAPHTHYLENE	1.3E+01	1.3E+01	3.0E+01
ACETONE	5.0E-01	5.0E-01	1.5E+03
ALDRIN	3.2E-02	1.3E-01	2.0E-03
ANTHRACENE	2.8E+00	2.8E+00	7.3E-01
ANTIMONY	6.1E+00	4.0E+01	6.0E+00
ARSENIC	5.5E+00	5.5E+00	3.6E+01
BARIUM	7.5E+02	1.5E+03	1.0E+03
BENZENE	4.4E-02	4.4E-02	1.0E+00
BENZO(a)ANTHRACENE	3.8E-01	1.3E+00	2.7E-02
BENZO(b)FLUORANTHENE	3.8E-01	1.3E+00	2.9E-02
BENZO(k)FLUORANTHENE	3.8E-01	1.3E+00	2.9E-02
BENZO(g,h,i)PERYLENE	2.7E+01	2.7E+01	1.0E-01
BENZO(a)PYRENE	3.8E-02	1.3E-01	1.4E-02
BERYLLIUM	4.0E+00	8.0E+00	2.7E+00
BIPHENYL, 1,1-	6.5E-01	6.5E-01	5.0E-01
BIS(2-CHLOROETHYL)ETHER	1.8E-04	1.8E-04	1.4E-02
BIS(2-CHLOROISOPROPYL)ETHER	5.4E-03	5.4E-03	5.0E-01
BIS(2-ETHYLHEXYL)PHTHALATE	6.6E+01	6.6E+01	4.0E+00
BORON	1.6E+00	2.0E+00	1.6E+00
BROMODICHLOROMETHANE	1.4E-02	3.9E-02	1.0E+02
BROMOFORM	2.2E+00	2.2E+00	1.0E+02
BROMOMETHANE	2.2E-01	3.9E-01	9.8E+00
CADMIUM	1.7E+00	7.4E+00	1.1E+00
CARBON TETRACHLORIDE	1.2E-02	3.4E-02	5.0E-01
CHLORDANE	4.4E-01	1.7E+00	4.0E-03
CHLOROANILINE, p-	5.3E-02	5.3E-02	5.0E+00
CHLOROBENZENE	1.5E+00	1.5E+00	2.5E+01
CHLOROETHANE	6.3E-01	8.5E-01	1.2E+01
CHLOROFORM	8.8E-01	1.9E+00	7.0E+01
CHLOROMETHANE	7.0E-02	2.0E-01	1.3E+00
CHLOROPHENOL, 2-	1.2E-02	1.2E-02	1.8E-01
CHROMIUM (Total)	5.8E+01	5.8E+01	5.0E+01
CHROMIUM III	7.5E+02	7.5E+02	1.8E+02
CHROMIUM VI	1.8E+00	1.8E+00	1.1E+01
CHRYSENE	3.8E+00	1.3E+01	2.9E-01
COBALT	1.0E+01	1.0E+01	3.0E+00
COPPER	2.3E+02	2.3E+02	3.1E+00
CYANIDE (Free)	3.6E-03	3.6E-03	1.0E+00
DIBENZO(a,h)ANTHTRACENE	1.1E-01	3.8E-01	8.5E-03
DIBROMOCHLOROMETHANE	1.9E-02	5.4E-02	1.0E+02
1,2-DIBROMO-3-CHLOROPROPANE	4.5E-03	4.5E-03	2.0E-01
DIBROMOETHANE, 1,2-	3.3E-04	3.3E-04	5.0E-02
DICHLOROBENZENE, 1,2-	1.1E+00	1.1E+00	1.0E+01

TABLE A. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS Current or Potential Source of Drinking Water

	[1]Shallow Soil		
CHEMICAL PARAMETER	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
DICHLOROBENZENE, 1,3-	7.4E+00	7.4E+00	6.5E+01
DICHLOROBENZENE, 1,4-	4.6E-02	1.3E-01	5.0E+00
DICHLOROBENZIDINE, 3,3-	7.7E-03	7.7E-03	2.9E-02
DICHLORODIPHENYLDICHLOROETHANE (DDD)	2.3E+00	9.0E+00	1.0E-03
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	1.6E+00	4.0E+00	1.0E-03
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	1.6E+00	4.0E+00	1.0E-03
DICHLOROETHANE, 1,1-	2.0E-01	2.0E-01	5.0E+00
DICHLOROETHANE, 1,2-	4.5E-03	4.5E-03	5.0E-01
DICHLOROETHYLENE, 1,1-	1.0E+00	1.0E+00	6.0E+00
DICHLOROETHYLENE, Cis 1,2-	1.9E-01	1.9E-01	6.0E+00
DICHLOROETHYLENE, Trans 1,2-	6.7E-01	6.7E-01	1.0E+01
DICHLOROPHENOL, 2,4-	3.0E-01	3.0E-01	3.0E-01
DICHLOROPROPANE, 1,2-	5.1E-02	1.2E-01	5.0E+00
DICHLOROPROPENE, 1,3-	3.3E-02	5.9E-02	5.0E-01
DIELDRIN	2.3E-03	2.3E-03	1.9E-03
DIETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHENOL, 2,4-	6.7E-01	6.7E-01	1.0E+02
DINITROPHENOL, 2,4-	4.0E-02	4.0E-02	1.4E+01
DINITROTOLUENE, 2,4-	8.5E-04	8.5E-04	1.1E-01
1,4 DIOXANE	1.8E-03	1.8E-03	3.0E+00
DIOXIN (2,3,7,8-TCDD)	4.6E-06	1.9E-05	5.0E-06
ENDOSULFAN	4.6E-03	4.6E-03	8.7E-03
ENDRIN	6.5E-04	6.5E-04	2.3E-03
ETHANOL	4.5E+01	4.5E+01	5.0E+04
ETHYLBENZENE	3.3E+00	3.3E+00	3.0E+01
FLUORANTHENE	4.0E+01	4.0E+01	8.0E+00
FLUORENE	8.9E+00	8.9E+00	3.9E+00
HEPTACHLOR	1.4E-02	1.4E-02	3.8E-03
HEPTACHLOR EPOXIDE	1.5E-02	1.5E-02	3.8E-03
HEXACHLOROBENZENE	2.7E-01	9.6E-01	1.0E+00
HEXACHLOROBUTADIENE	1.0E+00	1.0E+00	2.1E-01
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	4.9E-02	4.9E-02	8.0E-02
HEXACHLOROETHANE	2.4E+00	2.4E+00	7.0E-01
INDENO(1,2,3-cd)PYRENE	3.8E-01	1.3E+00	2.9E-02
LEAD	1.5E+02	7.5E+02	2.5E+00
MERCURY	3.7E+00	1.0E+01	1.2E-02
METHOXYCHLOR	1.9E+01	1.9E+01	1.9E-02
METHYLENE CHLORIDE	7.7E-02	7.7E-02	5.0E+00
METHYL ETHYL KETONE	3.9E+00	3.9E+00	4.2E+03
METHYL ISOBUTYL KETONE	2.8E+00	2.8E+00	1.2E+02
METHYL MERCURY	1.2E+00	1.0E+01	3.0E-03
METHYLNAPHTHALENE (total 1- & 2-)	2.5E-01	2.5E-01	2.1E+00
METHYL TERT BUTYL ETHER	2.3E-02	2.3E-02	5.0E+00

TABLE A. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS Current or Potential Source of Drinking Water

	[1]Shallow Soil		
CHEMICAL PARAMETER	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
MOLYBDENUM	4.0E+01	4.0E+01	3.5E+01
NAPHTHALENE	4.6E-01	1.5E+00	1.7E+01
NICKEL	1.5E+02	1.5E+02	8.2E+00
PENTACHLOROPHENOL	4.4E+00	5.0E+00	1.0E+00
PERCHLORATE	1.0E-02	1.0E-02	6.0E+00
PHENANTHRENE	1.1E+01	1.1E+01	4.6E+00
PHENOL	7.6E-02	7.6E-02	5.0E+00
POLYCHLORINATED BIPHENYLS (PCBs)	2.2E-01	7.4E-01	1.4E-02
PYRENE	8.5E+01	8.5E+01	2.0E+00
SELENIUM	1.0E+01	1.0E+01	5.0E+00
SILVER	2.0E+01	4.0E+01	1.9E-01
STYRENE	1.5E+00	1.5E+00	1.0E+01
tert-BUTYL ALCOHOL	7.3E-02	7.3E-02	1.2E+01
TETRACHLOROETHANE, 1,1,1,2-	2.4E-02	2.4E-02	1.3E+00
TETRACHLOROETHANE, 1,1,2,2-	9.1E-03	1.8E-02	1.0E+00
TETRACHLOROETHYLENE	8.7E-02	2.4E-01	5.0E+00
THALLIUM	1.0E+00	1.3E+01	2.0E+00
TOLUENE	2.9E+00	2.9E+00	4.0E+01
TOXAPHENE	4.2E-04	4.2E-04	2.0E-04
TPH (gasolines)	1.0E+02	1.0E+02	1.0E+02
TPH (middle distillates)	1.0E+02	1.0E+02	1.0E+02
TPH (residual fuels)	5.0E+02	1.0E+03	1.0E+02
TRICHLOROBENZENE, 1,2,4-	3.8E-01	1.0E+00	2.5E+01
TRICHLOROETHANE, 1,1,1-	7.8E+00	7.8E+00	6.2E+01
TRICHLOROETHANE, 1,1,2-	3.2E-02	7.0E-02	5.0E+00
TRICHLOROETHYLENE	2.6E-01	4.6E-01	5.0E+00
TRICHLOROPHENOL, 2,4,5-	1.8E-01	1.8E-01	1.1E+01
TRICHLOROPHENOL, 2,4,6-	1.7E-01	1.7E-01	5.0E-01
VANADIUM	1.1E+02	2.0E+02	1.5E+01
VINYL CHLORIDE	6.7E-03	1.9E-02	5.0E-01
XYLENES	2.3E+00	2.3E+00	2.0E+01
ZINC	6.0E+02	6.0E+02	8.1E+01

TABLE A. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils ($\leq$3m bgs)
Groundwater IS Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Shallow Soil [2]Residential Land Use (mg/kg)	[1]Shallow Soil Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	2.0	4.0	not applicable
Sodium Adsorption Ratio	5.0	12	not applicable

Red: Updated with respect to ESLs presented in July 2003 document.

Notes:

1. Shallow soils defined as soils less than or equal to 3 meters (approximately 10 feet) below ground surface.
2. Category "Residential Land Use" generally considered adequate for other sensitive uses (e.g., day-care centers, hospitals, etc.)
3. Assumes potential discharge of groundwater into a freshwater, marine or estuary surface water system.

Source of soil ESLs: Refer to Appendix 1, Tables A-1 and A-2.

Source of groundwater ESLs: Refer to Appendix 1, Table F-1a.

Soil data should be reported on dry-weight basis (see Appendix 1, Section 6.2).

Soil ESLs intended to address direct-exposure, groundwater protection, ecologic (urban areas) and nuisance concerns under noted land-use scenarios. **Soil gas data should be collected for additional evaluation of potential indoor-air impacts at sites with significant areas of VOC-impacted soil. See Section 2.6 and Table E.**

Groundwater ESLs intended to be address drinking water, surface water, indoor-air and nuisance concerns. **Use in conjunction with soil gas screening levels to more closely evaluate potential impacts to indoor-air if groundwater screening levels for this concern approached or exceeded (refer to Section 2.6 and Appendix 1, Table F-1a).**

Aquatic habitat goals for bioaccumulation concerns not considered in selection of groundwater goals (refer to Section 2.7).

Refer to appendices for summary of ESL components.

Soil and water ESLs for ethanol based on gross contamination concerns (see Appendix 1, Chapter 5 and related tables).

TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Volume 1, Section 2.2 and Appendix 1, Chapter 5.

TABLE B: SHALLOW SOIL ($\leq$3M BGS) - WATER <u>IS NOT</u> A CURRENT OR POTENTIAL SOURCE OF DRINKING WATER

Notes:
- Always compare final soil data for commercial/industrial sites to residential ESLs and evaluate need for formal land-use restrictions (see Section 2.10).
- Assumption that groundwater is not a current or potential source of drinking water should be approved by overseeing regulatory agency prior to use of this table (see Section 2.4).

TABLE B. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS NOT a Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Shallow Soil [2]Residential Land Use (mg/kg)	[1]Shallow Soil Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
ACENAPHTHENE	1.9E+01	1.9E+01	2.3E+01
ACENAPHTHYLENE	1.3E+01	1.3E+01	3.0E+01
ACETONE	5.0E-01	5.0E-01	1.5E+03
ALDRIN	3.2E-02	1.3E-01	1.3E-01
ANTHRACENE	2.8E+00	2.8E+00	7.3E-01
ANTIMONY	6.1E+00	4.0E+01	3.0E+01
ARSENIC	5.5E+00	5.5E+00	3.6E+01
BARIUM	7.5E+02	1.5E+03	1.0E+03
BENZENE	1.8E-01	3.8E-01	4.6E+01
BENZO(a)ANTHRACENE	3.8E-01	1.3E+00	2.7E-02
BENZO(b)FLUORANTHENE	3.8E-01	1.3E+00	2.9E-02
BENZO(k)FLUORANTHENE	3.8E-01	1.3E+00	4.0E-01
BENZO(g,h,i)PERYLENE	2.7E+01	2.7E+01	1.0E-01
BENZO(a)PYRENE	3.8E-02	1.3E-01	1.4E-02
BERYLLIUM	4.0E+00	8.0E+00	2.7E+00
BIPHENYL, 1,1-	6.5E+00	6.5E+00	5.0E+00
BIS(2-CHLOROETHYL)ETHER	3.7E-03	1.2E-02	6.1E+01
BIS(2-CHLOROISOPROPYL)ETHER	6.6E-01	6.6E-01	6.1E+01
BIS(2-ETHYLHEXYL)PHTHALATE	1.6E+02	5.3E+02	3.2E+01
BORON	1.6E+00	2.0E+00	1.6E+00
BROMODICHLOROMETHANE	1.4E-02	3.9E-02	1.7E+02
BROMOFORM	6.1E+01	6.9E+01	3.2E+03
BROMOMETHANE	2.2E-01	5.1E-01	1.6E+02
CADMIUM	1.7E+00	7.4E+00	1.1E+00
CARBON TETRACHLORIDE	1.2E-02	3.4E-02	9.3E+00
CHLORDANE	4.4E-01	1.7E+00	4.0E-03
CHLOROANILINE, p-	5.3E-02	5.3E-02	5.0E+00
CHLOROBENZENE	1.5E+00	1.5E+00	2.5E+01
CHLOROETHANE	6.3E-01	8.5E-01	1.2E+01
CHLOROFORM	8.8E-01	1.9E+00	3.3E+02
CHLOROMETHANE	7.0E-02	2.0E-01	4.1E+01
CHLOROPHENOL, 2-	1.2E-01	1.2E-01	1.8E+00
CHROMIUM (Total)	5.8E+01	5.8E+01	1.8E+02
CHROMIUM III	7.5E+02	7.5E+02	1.8E+02
CHROMIUM VI	1.8E+00	1.8E+00	1.1E+01
CHRYSENE	3.8E+00	1.3E+01	3.5E-01
COBALT	1.0E+01	1.0E+01	3.0E+00
COPPER	2.3E+02	2.3E+02	3.1E+00
CYANIDE (Free)	3.6E-03	3.6E-03	1.0E+00
DIBENZO(a,h)ANTHTRACENE	1.1E-01	3.8E-01	2.5E-01
DIBROMOCHLOROMETHANE	1.9E-02	5.4E-02	1.7E+02
1,2-DIBROMO-3-CHLOROPROPANE	4.5E-03	4.5E-03	2.0E-01
DIBROMOETHANE, 1,2-	7.3E-03	2.0E-02	1.5E+02
DICHLOROBENZENE, 1,2-	1.6E+00	1.6E+00	1.4E+01

TABLE B. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS NOT a Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Shallow Soil [2]Residential Land Use (mg/kg)	[1]Shallow Soil Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
DICHLOROBENZENE, 1,3-	7.4E+00	7.4E+00	6.5E+01
DICHLOROBENZENE, 1,4-	4.6E-02	1.3E-01	1.5E+01
DICHLOROBENZIDINE, 3,3-	4.0E-01	1.4E+00	2.5E+02
DICHLORODIPHENYLDICHLOROETHANE (DDD)	2.3E+00	9.0E+00	1.0E-03
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	1.6E+00	4.0E+00	1.0E-03
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	1.6E+00	4.0E+00	1.0E-03
DICHLOROETHANE, 1,1-	3.2E-01	8.9E-01	4.7E+01
DICHLOROETHANE, 1,2-	2.5E-02	7.0E-02	2.0E+02
DICHLOROETHYLENE, 1,1-	4.3E+00	4.3E+00	2.5E+01
DICHLOROETHYLENE, Cis 1,2-	1.6E+00	3.6E+00	5.9E+02
DICHLOROETHYLENE, Trans 1,2-	3.1E+00	7.3E+00	5.9E+02
DICHLOROPHENOL, 2,4-	3.0E+00	3.0E+00	3.0E+00
DICHLOROPROPANE, 1,2-	5.1E-02	1.4E-01	1.0E+02
DICHLOROPROPENE, 1,3-	3.3E-02	9.3E-02	5.3E+01
DIELDRIN	2.3E-03	2.3E-03	1.9E-03
DIETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHENOL, 2,4-	7.4E-01	7.4E-01	1.1E+02
DINITROPHENOL, 2,4-	2.1E-01	2.1E-01	7.5E+01
DINITROTOLUENE, 2,4-	8.6E-01	8.6E-01	1.2E+02
1,4 DIOXANE	1.8E+01	3.0E+01	5.0E+04
DIOXIN (2,3,7,8-TCDD)	4.6E-06	1.9E-05	5.0E-06
ENDOSULFAN	4.6E-03	4.6E-03	8.7E-03
ENDRIN	6.5E-04	6.5E-04	2.3E-03
ETHANOL	4.5E+01	4.5E+01	5.0E+04
ETHYLBENZENE	3.2E+01	3.2E+01	2.9E+02
FLUORANTHENE	4.0E+01	4.0E+01	8.0E+00
FLUORENE	8.9E+00	8.9E+00	3.9E+00
HEPTACHLOR	1.4E-02	1.4E-02	3.8E-03
HEPTACHLOR EPOXIDE	1.5E-02	1.5E-02	3.8E-03
HEXACHLOROBENZENE	2.7E-01	9.6E-01	3.7E+00
HEXACHLOROBUTADIENE	3.7E+00	2.2E+01	4.7E+00
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	4.9E-02	4.9E-02	8.0E-02
HEXACHLOROETHANE	1.2E+01	4.1E+01	1.2E+01
INDENO(1,2,3-cd)PYRENE	3.8E-01	1.3E+00	2.9E-02
LEAD	1.5E+02	7.5E+02	2.5E+00
MERCURY	3.7E+00	1.0E+01	1.2E-02
METHOXYCHLOR	1.9E+01	1.9E+01	1.9E-02
METHYLENE CHLORIDE	5.2E-01	1.5E+00	2.2E+03
METHYL ETHYL KETONE	1.3E+01	1.3E+01	1.4E+04
METHYL ISOBUTYL KETONE	3.9E+00	3.9E+00	1.7E+02
METHYL MERCURY	1.2E+00	1.0E+01	3.0E-03
METHYLNAPHTHALENE (total 1- & 2-)	2.5E-01	2.5E-01	2.1E+00
METHYL TERT BUTYL ETHER	2.0E+00	5.6E+00	1.8E+03

TABLE B. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils ($\leq$3m bgs)
Groundwater IS NOT a Current or Potential Source of Drinking Water

	[1]Shallow Soil		
CHEMICAL PARAMETER	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
MOLYBDENUM	4.0E+01	4.0E+01	2.4E+02
NAPHTHALENE	4.6E-01	1.5E+00	2.4E+01
NICKEL	1.5E+02	1.5E+02	8.2E+00
PENTACHLOROPHENOL	4.4E+00	5.0E+00	7.9E+00
PERCHLORATE	1.2E+00	1.2E+00	6.0E+02
PHENANTHRENE	1.1E+01	1.1E+01	4.6E+00
PHENOL	1.9E+01	1.9E+01	1.3E+03
POLYCHLORINATED BIPHENYLS (PCBs)	2.2E-01	7.4E-01	1.4E-02
PYRENE	8.5E+01	8.5E+01	2.0E+00
SELENIUM	1.0E+01	1.0E+01	5.0E+00
SILVER	2.0E+01	4.0E+01	1.9E-01
STYRENE	1.5E+01	1.5E+01	1.0E+02
tert-BUTYL ALCOHOL	5.7E+01	1.1E+02	1.8E+04
TETRACHLOROETHANE, 1,1,1,2-	3.0E+00	6.9E+00	9.3E+02
TETRACHLOROETHANE, 1,1,2,2-	9.1E-03	2.5E-02	1.9E+02
TETRACHLOROETHYLENE	8.7E-02	2.4E-01	1.2E+02
THALLIUM	1.0E+00	1.3E+01	2.0E+01
TOLUENE	9.3E+00	9.3E+00	1.3E+02
TOXAPHENE	4.2E-04	4.2E-04	2.0E-04
TPH (gasolines)	1.0E+02	4.0E+02	5.0E+02
TPH (middle distillates)	1.0E+02	5.0E+02	6.4E+02
TPH (residual fuels)	5.0E+02	1.0E+03	6.4E+02
TRICHLOROBENZENE, 1,2,4-	3.8E-01	1.0E+00	2.5E+01
TRICHLOROETHANE, 1,1,1-	7.8E+00	7.8E+00	6.2E+01
TRICHLOROETHANE, 1,1,2-	3.2E-02	8.9E-02	3.5E+02
TRICHLOROETHYLENE	2.6E-01	7.3E-01	3.6E+02
TRICHLOROPHENOL, 2,4,5-	1.8E-01	1.8E-01	1.1E+01
TRICHLOROPHENOL, 2,4,6-	6.9E+00	1.0E+01	4.9E+02
VANADIUM	1.1E+02	2.0E+02	1.9E+01

TABLE B. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Shallow Soils (≤3m bgs)
Groundwater IS NOT a Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Shallow Soil [2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
VINYL CHLORIDE	6.7E-03	1.9E-02	3.8E+00
XYLENES	1.1E+01	1.1E+01	1.0E+02
ZINC	6.0E+02	6.0E+02	8.1E+01
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	2.0	4.0	not applicable
Sodium Adsorption Ratio	5.0	12	not applicable

Red: Updated with respect to ESLs presented in July 2003 document.

Notes:

1. Shallow soils defined as soils less than or equal to 3 meters (approximately 10 feet) below ground surface.
2. Category "Residential Land Use" generally considered adequate for other sensitive uses (e.g., day-care centers, hospitals, etc.)
3. Assumes potential discharge of groundwater into marine or estuary surface water system.

Source of soil ESLs: Refer to Appendix 1, Tables A-1 and A-2.

Source of groundwater ESLs: Refer to Appendix 1, Table F-1b.

Soil data should be reported on dry-weight basis (see Appendix 1, Section 6.2).

Soil ESLs intended to address direct-exposure, groundwater protection, ecologic (urban areas) and nuisance concerns under noted land-use scenarios. **Soil gas data should be collected for additional evaluation of potential indoor-air impacts at at sites with significant areas of VOC-impacted soil. See Section 2.6 and Table E.**

Groundwater ESLs intended to address surface water, indoor-air and nuisance concerns. **Use in conjunction with soil gas screening levels to more closely evaluate potential impacts to indoor-air if groundwater screening levels for this concern approached or exceeded (refer to Section 2.6 and Appendix 1, Table F-1a).**

Aquatic habitat goals for bioaccumulation concerns not considered in selection of groundwater goals (refer to Section 2.7).

Refer to appendices for summary of ESL components.

Soil and water ESLs for ethanol based on gross contamination concerns (see Appendix 1, Chapter 5 and related tables).

TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Volume 1, Section 2.2 and Appendix 1, Chapter 5.

TABLE C: DEEP SOIL (>3M BGS) - WATER IS A CURRENT OR POTENTIAL SOURCE OF DRINKING WATER

Notes:
- Always compare final soil data for commercial/industrial sites to residential ESLs and evaluate need for formal land-use restrictions (see Section 2.10).
- ESLs for deep soils may be applicable to soils <3m below ground surface at commercial/industrial sites provided institutional controls are put in place to maintain an adequate cap and provide proper management of soil if exposed in future (see Section 2.5 and Section 2.10).

TABLE C. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Deep Soils (>3m bgs)
Groundwater IS a Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Deep Soil [2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
ACENAPHTHENE	1.6E+01	1.6E+01	2.0E+01
ACENAPHTHYLENE	1.3E+01	1.3E+01	3.0E+01
ACETONE	5.0E-01	5.0E-01	1.5E+03
ALDRIN	1.5E+00	1.5E+00	2.0E-03
ANTHRACENE	2.8E+00	2.8E+00	7.3E-01
ANTIMONY	2.8E+02	2.8E+02	6.0E+00
ARSENIC	5.5E+00	5.5E+00	3.6E+01
BARIUM	2.5E+03	2.5E+03	1.0E+03
BENZENE	4.4E-02	4.4E-02	1.0E+00
BENZO(a)ANTHRACENE	1.2E+01	1.2E+01	2.7E-02
BENZO(b)FLUORANTHENE	1.5E+01	1.5E+01	2.9E-02
BENZO(k)FLUORANTHENE	2.7E+00	2.7E+00	2.9E-02
BENZO(g,h,i)PERYLENE	2.7E+01	2.7E+01	1.0E-01
BENZO(a)PYRENE	1.5E+00	1.5E+00	1.4E-02
BERYLLIUM	3.6E+01	3.6E+01	2.7E+00
BIPHENYL, 1,1-	6.5E-01	6.5E-01	5.0E-01
BIS(2-CHLOROETHYL)ETHER	1.8E-04	1.8E-04	1.4E-02
BIS(2-CHLOROISOPROPYL)ETHER	5.4E-03	5.4E-03	5.0E-01
BIS(2-ETHYLHEXYL)PHTHALATE	6.6E+01	6.6E+01	4.0E+00
BORON	4.6E+04	4.6E+04	1.6E+00
BROMODICHLOROMETHANE	1.4E-02	3.9E-02	1.0E+02
BROMOFORM	2.2E+00	2.2E+00	1.0E+02
BROMOMETHANE	2.2E-01	3.9E-01	9.8E+00
CADMIUM	3.8E+01	3.8E+01	1.1E+00
CARBON TETRACHLORIDE	1.2E-02	3.4E-02	5.0E-01
CHLORDANE	1.5E+01	1.5E+01	4.0E-03
CHLOROANILINE, p-	5.3E-02	5.3E-02	5.0E+00
CHLOROBENZENE	1.5E+00	1.5E+00	2.5E+01
CHLOROETHANE	6.3E-01	8.5E-01	1.2E+01
CHLOROFORM	2.1E+00	2.1E+00	7.0E+01
CHLOROMETHANE	7.0E-02	2.0E-01	1.3E+00
CHLOROPHENOL, 2-	1.2E-02	1.2E-02	1.8E-01
CHROMIUM (Total)	5.8E+01	5.8E+01	5.0E+01
CHROMIUM III	2.5E+03	5.0E+03	1.8E+02
CHROMIUM VI	1.8E+00	1.8E+00	1.1E+01
CHRYSENE	1.9E+01	1.9E+01	2.9E-01
COBALT	1.0E+01	1.0E+01	3.0E+00
COPPER	2.5E+03	5.0E+03	3.1E+00
CYANIDE (Free)	3.6E-03	3.6E-03	1.0E+00
DIBENZO(a,h)ANTHTRACENE	4.3E+00	4.3E+00	8.5E-03
DIBROMOCHLOROMETHANE	1.9E-02	5.4E-02	1.0E+02
1,2-DIBROMO-3-CHLOROPROPANE	4.5E-03	4.5E-03	2.0E-01
DIBROMOETHANE, 1,2-	3.3E-04	3.3E-04	5.0E-02
DICHLOROBENZENE, 1,2-	1.1E+00	1.1E+00	1.0E+01

TABLE C. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Deep Soils (>3m bgs)
Groundwater IS a Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Deep Soil [2]Residential Land Use (mg/kg)	[1]Deep Soil Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
DICHLOROBENZENE, 1,3-	7.4E+00	7.4E+00	6.5E+01
DICHLOROBENZENE, 1,4-	4.6E-02	1.3E-01	5.0E+00
DICHLOROBENZIDINE, 3,3-	7.7E-03	7.7E-03	2.9E-02
DICHLORODIPHENYLDICHLOROETHANE (DDD)	1.1E+02	1.1E+02	1.0E-03
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	7.6E+01	7.6E+01	1.0E-03
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	4.3E+00	4.3E+00	1.0E-03
DICHLOROETHANE, 1,1-	2.0E-01	2.0E-01	5.0E+00
DICHLOROETHANE, 1,2-	4.5E-03	4.5E-03	5.0E-01
DICHLOROETHYLENE, 1,1-	1.0E+00	1.0E+00	6.0E+00
DICHLOROETHYLENE, Cis 1,2-	1.9E-01	1.9E-01	6.0E+00
DICHLOROETHYLENE, Trans 1,2-	6.7E-01	6.7E-01	1.0E+01
DICHLOROPHENOL, 2,4-	3.0E-01	3.0E-01	3.0E-01
DICHLOROPROPANE, 1,2-	5.1E-02	1.2E-01	5.0E+00
DICHLOROPROPENE, 1,3-	3.3E-02	5.9E-02	5.0E-01
DIELDRIN	2.3E-03	2.3E-03	1.9E-03
DIETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHENOL, 2,4-	6.7E-01	6.7E-01	1.0E+02
DINITROPHENOL, 2,4-	4.0E-02	4.0E-02	1.4E+01
DINITROTOLUENE, 2,4-	8.5E-04	8.5E-04	1.1E-01
1,4 DIOXANE	1.8E-03	1.8E-03	3.0E+00
DIOXIN (2,3,7,8-TCDD)	2.4E-04	2.4E-04	5.0E-06
ENDOSULFAN	4.6E-03	4.6E-03	8.7E-03
ENDRIN	6.5E-04	6.5E-04	2.3E-03
ETHANOL	4.5E+01	4.5E+01	5.0E+04
ETHYLBENZENE	3.3E+00	3.3E+00	3.0E+01
FLUORANTHENE	6.0E+01	6.0E+01	8.0E+00
FLUORENE	8.9E+00	8.9E+00	3.9E+00
HEPTACHLOR	1.4E-02	1.4E-02	3.8E-03
HEPTACHLOR EPOXIDE	1.5E-02	1.5E-02	3.8E-03
HEXACHLOROBENZENE	1.1E+01	1.1E+01	1.0E+00
HEXACHLOROBUTADIENE	1.0E+00	1.0E+00	2.1E-01
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	4.9E-02	4.9E-02	8.0E-02
HEXACHLOROETHANE	2.4E+00	2.4E+00	7.0E-01
INDENO(1,2,3-cd)PYRENE	7.7E+00	7.7E+00	2.9E-02
LEAD	7.5E+02	7.5E+02	2.5E+00
MERCURY	9.8E+01	9.8E+01	1.2E-02
METHOXYCHLOR	1.9E+01	1.9E+01	1.9E-02
METHYLENE CHLORIDE	7.7E-02	7.7E-02	5.0E+00
METHYL ETHYL KETONE	3.9E+00	3.9E+00	4.2E+03
METHYL ISOBUTYL KETONE	2.8E+00	2.8E+00	1.2E+02
METHYL MERCURY	4.1E+01	4.1E+01	3.0E-03
METHYLNAPHTHALENE (total 1- & 2-)	2.5E-01	2.5E-01	2.1E+00
METHYL TERT BUTYL ETHER	2.3E-02	2.3E-02	5.0E+00

TABLE C. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Deep Soils (>3m bgs)
Groundwater IS a Current or Potential Source of Drinking Water

	[1]Deep Soil		
CHEMICAL PARAMETER	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
MOLYBDENUM	2.5E+03	3.6E+03	3.5E+01
NAPHTHALENE	4.6E-01	1.5E+00	1.7E+01
NICKEL	1.0E+03	1.0E+03	8.2E+00
PENTACHLOROPHENOL	5.3E+00	5.3E+00	1.0E+00
PERCHLORATE	1.0E-02	1.0E-02	6.0E+00
PHENANTHRENE	1.1E+01	1.1E+01	4.6E+00
PHENOL	7.6E-02	7.6E-02	5.0E+00
POLYCHLORINATED BIPHENYLS (PCBs)	6.3E+00	6.3E+00	1.4E-02
PYRENE	8.5E+01	8.5E+01	2.0E+00
SELENIUM	2.5E+03	3.4E+03	5.0E+00
SILVER	2.5E+03	3.6E+03	1.9E-01
STYRENE	1.5E+00	1.5E+00	1.0E+01
tert-BUTYL ALCOHOL	7.3E-02	7.3E-02	1.2E+01
TETRACHLOROETHANE, 1,1,1,2-	2.4E-02	2.4E-02	1.3E+00
TETRACHLOROETHANE, 1,1,2,2-	9.1E-03	1.8E-02	1.0E+00
TETRACHLOROETHYLENE	8.7E-02	2.4E-01	5.0E+00
THALLIUM	4.7E+01	4.7E+01	2.0E+00
TOLUENE	2.9E+00	2.9E+00	4.0E+01
TOXAPHENE	4.2E-04	4.2E-04	2.0E-04
TPH (gasolines)	1.0E+02	1.0E+02	1.0E+02
TPH (middle distillates)	1.0E+02	1.0E+02	1.0E+02
TPH (residual fuels)	1.0E+03	1.0E+03	1.0E+02
TRICHLOROBENZENE, 1,2,4-	3.8E-01	1.0E+00	2.5E+01
TRICHLOROETHANE, 1,1,1-	7.8E+00	7.8E+00	6.2E+01
TRICHLOROETHANE, 1,1,2-	3.2E-02	7.0E-02	5.0E+00
TRICHLOROETHYLENE	2.6E-01	4.6E-01	5.0E+00
TRICHLOROPHENOL, 2,4,5-	1.8E-01	1.8E-01	1.1E+01
TRICHLOROPHENOL, 2,4,6-	1.7E-01	1.7E-01	5.0E-01
VANADIUM	2.5E+03	5.0E+03	1.5E+01

TABLE C. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Deep Soils (>3m bgs)
Groundwater IS a Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Deep Soil [2]Residential Land Use (mg/kg)	[1]Deep Soil Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
VINYL CHLORIDE	6.7E-03	1.9E-02	5.0E-01
XYLENES	2.3E+00	2.3E+00	2.0E+01
ZINC	2.5E+03	5.0E+03	8.1E+01
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	not applicable	not applicable	not applicable
Sodium Adsorption Ratio	not applcable	not applicable	not applicable

Red: Updated with respect to ESLs presented in July 2003 document.

Notes:

1. Deep soils defined as soils greater than 3 meters (approximately 10 feet) below ground surface.
2. Category "Residential Land Use" generally considered adequate for other sensitive uses (e.g., day-care centers, hospitals, etc.)
3. Assumes potential discharge of groundwater into a freshwater, marine or estuary surface water system.

Source of soil ESLs: Refer to Appendix 1, Tables C-1 and C-2.

Source of groundwater ESLs: Refer to Appendix 1, Table F-1a.

Soil data should be reported on dry-weight basis (see Appendix 1, Section 6.2).

Soil ESLs intended to address human health, groundwater protection and nuisance concerns under a construction/trench worker exposure scenario and noted land-use scenarios. **Soil gas data should be collected for additional evaluation of potential indoor-air impacts at sites with significant areas of VOC-impacted soil. See Section 2.6 and Table E.**

Groundwater ESLs intended to be address drinking water, surface water, indoor-air and nuisance concerns. **Use in conjunction with soil gas screening levels to more closely evaluate potential impacts to indoor-air if groundwater screening levels for this concern approached or exceeded (refer to Section 2.6 and Appendix 1, Table F-1a).**

Aquatic habitat goals for bioaccumulation concerns not considered in selection of groundwater goals (refer to Section 2.7).

Refer to appendices for summary of ESL components.

Soil and water ESLs for ethanol based on gross contamination concerns (see Appendix 1, Chapter 5 and related tables).

TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Volume 1, Section 2.2 and Appendix 1, Chapter 5.

TABLE D: DEEP SOIL (>3M BGS) - WATER <u>IS NOT</u> A CURRENT OR POTENTIAL SOURCE OF DRINKING WATER

Notes:

- Always compare final soil data for commercial/industrial sites to residential ESLs and evaluate need for formal land-use restrictions (see Section 2.10).
- Assumption that groundwater is not a current or potential source of drinking water should be approved by overseeing regulatory agency prior to use of this table (see Section 2.4).
- ESLs for deep soils may be applicable to soils <3m below ground surface at commercial/industrial sites provided institutional controls are put in place to maintain an adequate cap and provide proper management of soil if exposed in future (see Section 2.5 and Section 2.10).

TABLE D. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Deep Soils (>3m bgs)
Groundwater IS NOT a Current or Potential Source of Drinking Water

	[1]Deep Soil		
CHEMICAL PARAMETER	[2]Residential Land Use (mg/kg)	Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
ACENAPHTHENE	1.9E+01	1.9E+01	2.3E+01
ACENAPHTHYLENE	1.3E+01	1.3E+01	3.0E+01
ACETONE	5.0E-01	5.0E-01	1.5E+03
ALDRIN	1.5E+00	1.5E+00	1.3E-01
ANTHRACENE	2.8E+00	2.8E+00	7.3E-01
ANTIMONY	2.8E+02	2.8E+02	3.0E+01
ARSENIC	5.5E+00	5.5E+00	3.6E+01
BARIUM	2.5E+03	2.5E+03	1.0E+03
BENZENE	1.8E-01	5.1E-01	4.6E+01
BENZO(a)ANTHRACENE	1.2E+01	1.2E+01	2.7E-02
BENZO(b)FLUORANTHENE	1.5E+01	1.5E+01	2.9E-02
BENZO(k)FLUORANTHENE	1.5E+01	1.5E+01	4.0E-01
BENZO(g,h,i)PERYLENE	2.7E+01	2.7E+01	1.0E-01
BENZO(a)PYRENE	1.5E+00	1.5E+00	1.4E-02
BERYLLIUM	3.6E+01	3.6E+01	2.7E+00
BIPHENYL, 1,1-	6.5E+00	6.5E+00	5.0E+00
BIS(2-CHLOROETHYL)ETHER	3.7E-03	1.2E-02	6.1E+01
BIS(2-CHLOROISOPROPYL)ETHER	6.6E-01	6.6E-01	6.1E+01
BIS(2-ETHYLHEXYL)PHTHALATE	5.3E+02	5.3E+02	3.2E+01
BORON	4.6E+04	4.6E+04	1.6E+00
BROMODICHLOROMETHANE	1.4E-02	3.9E-02	1.7E+02
BROMOFORM	6.9E+01	6.9E+01	3.2E+03
BROMOMETHANE	2.2E-01	5.1E-01	1.6E+02
CADMIUM	3.8E+01	3.8E+01	1.1E+00
CARBON TETRACHLORIDE	1.2E-02	3.4E-02	9.3E+00
CHLORDANE	1.5E+01	1.5E+01	4.0E-03
CHLOROANILINE, p-	5.3E-02	5.3E-02	5.0E+00
CHLOROBENZENE	1.5E+00	1.5E+00	2.5E+01
CHLOROETHANE	6.3E-01	8.5E-01	1.2E+01
CHLOROFORM	9.8E+00	9.8E+00	3.3E+02
CHLOROMETHANE	7.0E-02	2.0E-01	4.1E+01
CHLOROPHENOL, 2-	1.2E-01	1.2E-01	1.8E+00
CHROMIUM (Total)	5.8E+01	5.8E+01	1.8E+02
CHROMIUM III	2.5E+03	5.0E+03	1.8E+02
CHROMIUM VI	1.8E+00	1.8E+00	1.1E+01
CHRYSENE	2.3E+01	2.3E+01	3.5E-01
COBALT	1.0E+01	1.0E+01	3.0E+00
COPPER	2.5E+03	5.0E+03	3.1E+00
CYANIDE (Free)	3.6E-03	3.6E-03	1.0E+00
DIBENZO(a,h)ANTHTRACENE	4.3E+00	4.3E+00	2.5E-01
DIBROMOCHLOROMETHANE	1.9E-02	5.4E-02	1.7E+02
1,2-DIBROMO-3-CHLOROPROPANE	4.5E-03	4.5E-03	2.0E-01
DIBROMOETHANE, 1,2-	7.3E-03	2.0E-02	1.5E+02
DICHLOROBENZENE, 1,2-	1.6E+00	1.6E+00	1.4E+01

TABLE D. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Deep Soils (>3m bgs)
Groundwater IS NOT a Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Deep Soil [2]Residential Land Use (mg/kg)	[1]Deep Soil Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
DICHLOROBENZENE, 1,3-	7.4E+00	7.4E+00	6.5E+01
DICHLOROBENZENE, 1,4-	4.6E-02	1.3E-01	1.5E+01
DICHLOROBENZIDINE, 3,3-	1.7E+01	1.7E+01	2.5E+02
DICHLORODIPHENYLDICHLOROETHANE (DDD)	1.1E+02	1.1E+02	1.0E-03
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	7.6E+01	7.6E+01	1.0E-03
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	4.3E+00	4.3E+00	1.0E-03
DICHLOROETHANE, 1,1-	3.2E-01	8.9E-01	4.7E+01
DICHLOROETHANE, 1,2-	2.5E-02	7.0E-02	2.0E+02
DICHLOROETHYLENE, 1,1-	4.3E+00	4.3E+00	2.5E+01
DICHLOROETHYLENE, Cis 1,2-	1.6E+00	3.6E+00	5.9E+02
DICHLOROETHYLENE, Trans 1,2-	3.1E+00	7.3E+00	5.9E+02
DICHLOROPHENOL, 2,4-	3.0E+00	3.0E+00	3.0E+00
DICHLOROPROPANE, 1,2-	5.1E-02	1.4E-01	1.0E+02
DICHLOROPROPENE, 1,3-	3.3E-02	9.3E-02	5.3E+01
DIELDRIN	2.3E-03	2.3E-03	1.9E-03
DIETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHTHALATE	3.5E-02	3.5E-02	1.5E+00
DIMETHYLPHENOL, 2,4-	7.4E-01	7.4E-01	1.1E+02
DINITROPHENOL, 2,4-	2.1E-01	2.1E-01	7.5E+01
DINITROTOLUENE, 2,4-	8.6E-01	8.6E-01	1.2E+02
1,4 DIOXANE	3.0E+01	3.0E+01	5.0E+04
DIOXIN (2,3,7,8-TCDD)	2.4E-04	2.4E-04	5.0E-06
ENDOSULFAN	4.6E-03	4.6E-03	8.7E-03
ENDRIN	6.5E-04	6.5E-04	2.3E-03
ETHANOL	4.5E+01	4.5E+01	5.0E+04
ETHYLBENZENE	3.2E+01	3.2E+01	2.9E+02
FLUORANTHENE	6.0E+01	6.0E+01	8.0E+00
FLUORENE	8.9E+00	8.9E+00	3.9E+00
HEPTACHLOR	1.4E-02	1.4E-02	3.8E-03
HEPTACHLOR EPOXIDE	1.5E-02	1.5E-02	3.8E-03
HEXACHLOROBENZENE	1.1E+01	1.1E+01	3.7E+00
HEXACHLOROBUTADIENE	2.3E+01	2.3E+01	4.7E+00
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	4.9E-02	4.9E-02	8.0E-02
HEXACHLOROETHANE	4.1E+01	4.1E+01	1.2E+01
INDENO(1,2,3-cd)PYRENE	7.7E+00	7.7E+00	2.9E-02
LEAD	7.5E+02	7.5E+02	2.5E+00
MERCURY	9.8E+01	9.8E+01	1.2E-02
METHOXYCHLOR	1.9E+01	1.9E+01	1.9E-02
METHYLENE CHLORIDE	5.2E-01	1.5E+00	2.2E+03
METHYL ETHYL KETONE	1.3E+01	1.3E+01	1.4E+04
METHYL ISOBUTYL KETONE	3.9E+00	3.9E+00	1.7E+02
METHYL MERCURY	4.1E+01	4.1E+01	3.0E-03
METHYLNAPHTHALENE (total 1- & 2-)	2.5E-01	2.5E-01	2.1E+00
METHYL TERT BUTYL ETHER	2.0E+00	5.6E+00	1.8E+03

TABLE D. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Deep Soils (>3m bgs)
Groundwater IS NOT a Current or Potential Source of Drinking Water

CHEMICAL PARAMETER	[1]Deep Soil [2]Residential Land Use (mg/kg)	[1]Deep Soil Commercial/ Industrial Land Use Only (mg/kg)	[3]Groundwater (ug/L)
MOLYBDENUM	2.5E+03	3.6E+03	2.4E+02
NAPHTHALENE	4.6E-01	1.5E+00	2.4E+01
NICKEL	1.0E+03	1.0E+03	8.2E+00
PENTACHLOROPHENOL	4.2E+01	4.2E+01	7.9E+00
PERCHLORATE	1.2E+00	1.2E+00	6.0E+02
PHENANTHRENE	1.1E+01	1.1E+01	4.6E+00
PHENOL	1.9E+01	1.9E+01	1.3E+03
POLYCHLORINATED BIPHENYLS (PCBs)	6.3E+00	6.3E+00	1.4E-02
PYRENE	8.5E+01	8.5E+01	2.0E+00
SELENIUM	2.5E+03	3.4E+03	5.0E+00
SILVER	2.5E+03	3.6E+03	1.9E-01
STYRENE	1.5E+01	1.5E+01	1.0E+02
tert-BUTYL ALCOHOL	1.1E+02	1.1E+02	1.8E+04
TETRACHLOROETHANE, 1,1,1,2-	1.6E+01	1.6E+01	9.3E+02
TETRACHLOROETHANE, 1,1,2,2-	9.1E-03	2.5E-02	1.9E+02
TETRACHLOROETHYLENE	8.7E-02	2.4E-01	1.2E+02
THALLIUM	4.7E+01	4.7E+01	2.0E+01
TOLUENE	9.3E+00	9.3E+00	1.3E+02
TOXAPHENE	4.2E-04	4.2E-04	2.0E-04
TPH (gasolines)	4.0E+02	4.0E+02	5.0E+02
TPH (middle distillates)	5.0E+02	5.0E+02	6.4E+02
TPH (residual fuels)	1.0E+03	1.0E+03	6.4E+02
TRICHLOROBENZENE, 1,2,4-	3.8E-01	1.0E+00	2.5E+01
TRICHLOROETHANE, 1,1,1-	7.8E+00	7.8E+00	6.2E+01
TRICHLOROETHANE, 1,1,2-	3.2E-02	8.9E-02	3.5E+02
TRICHLOROETHYLENE	2.6E-01	7.3E-01	3.6E+02
TRICHLOROPHENOL, 2,4,5-	1.8E-01	1.8E-01	1.1E+01
TRICHLOROPHENOL, 2,4,6-	1.6E+02	1.6E+02	4.9E+02
VANADIUM	2.5E+03	5.0E+03	1.9E+01

TABLE D. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Deep Soils (>3m bgs)
Groundwater IS NOT a Current or Potential Source of Drinking Water

	[1]Deep Soil		
CHEMICAL PARAMETER	**[2]Residential Land Use (mg/kg)**	**Commercial/ Industrial Land Use Only (mg/kg)**	**[3]Groundwater (ug/L)**
VINYL CHLORIDE	6.7E-03	1.9E-02	3.8E+00
XYLENES	1.1E+01	1.1E+01	1.0E+02
ZINC	2.5E+03	5.0E+03	8.1E+01
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	not applicable	not applicable	not applicable
Sodium Adsorption Ratio	not applicable	not applicable	not applicable

Red: Updated with respect to ESLs presented in July 2003 document.

Notes:

1. Deep soils defined as soils greater than 3 meters (approximately 10 feet) below ground surface.
2. Category "Residential Land Use" generally considered adequate for other sensitive uses (e.g., day-care centers, hospitals, etc.)
3. Assumes potential discharge of groundwater into marine or estuary surface water system.

Source of soil ESLs: Refer to Appendix 1, Tables D-1 and D-2.
Source of groundwater ESLs: Refer to Appendix 1, Table F-1b.
Soil data should be reported on dry-weight basis (see Appendix 1, Section 6.2).
Soil ESLs intended to address human health, groundwater protection and nuisance concerns under a construction/trench worker exposure scenario and noted land-use scenarios. **Soil gas data should be collected for additional evaluation of potential indoor-air impacts at sites with significant areas of VOC-impacted soil. See Section 2.6 and Table E.**
Groundwater ESLs intended to address surface water, indoor-air and nuisance concerns. **Use in conjunction with soil gas screening levels to more closely evaluate potential impacts to indoor-air if groundwater screening levels for this concern approached or exceeded (refer to Section 2.6 and Appendix 1, Table F-1a).**
Aquatic habitat goals for bioaccumulation concerns not considered in selection of groundwater goals (refer to Section 2.7).
Refer to appendices for summary of ESL components.
Soil and water ESLs for ethanol based on gross contamination concerns (see Appendix 1, Chapter 5 and related tables).
TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Volume 1, Section 2.2 and Appendix 1, Chapter 5.

TABLE E: SHALLOW SOIL GAS AND INDOOR AIR

Notes:

- Shallow soil gas intended to reflect soil gas zero to five feet below ground surface or the foundation of a building. Collection of soil gas data from depths <3 feet below ground surface in open areas is generally not practical (see Section 2.6).

TABLE E. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Indoor Air and Soil Gas
(Vapor Intrusion Concerns)

CHEMICAL PARAMETER	INDOOR AIR SCREENING LEVELS: [1]Residential Land Use (ug/m3)	INDOOR AIR SCREENING LEVELS: Commercial/ Industrial Land Use Only (ug/m^3)	[2]SHALLOW SOIL GAS SCREENING LEVELS: [1]Residential Land Use (ug/m3)	[2]SHALLOW SOIL GAS SCREENING LEVELS: Commercial/ Industrial Land Use Only (ug/m^3)
ACENAPHTHENE	4.4E+01	6.1E+01	4.4E+04	1.2E+05
ACENAPHTHYLENE	2.9E+01	4.1E+01	2.9E+04	8.2E+04
ACETONE	6.6E+02	9.2E+02	6.6E+05	1.8E+06
ALDRIN				
ANTHRACENE	2.2E+02	3.1E+02	2.2E+05	6.1E+05
ANTIMONY				
ARSENIC				
BARIUM				
BENZENE	8.5E-02	1.4E-01	8.5E+01	2.9E+02
BENZO(a)ANTHRACENE				
BENZO(b)FLUORANTHENE				
BENZO(k)FLUORANTHENE				
BENZO(g,h,i)PERYLENE				
BENZO(a)PYRENE				
BERYLLIUM				
BIPHENYL, 1,1-	3.7E+01	5.1E+01	3.7E+04	1.0E+05
BIS(2-CHLOROETHYL)ETHER	3.4E-03	5.7E-03	3.4E+00	1.1E+01
BIS(2-CHLOROISOPROPYL)ETHER	2.4E-01	4.1E-01	2.4E+02	8.2E+02
BIS(2-ETHYLHEXYL)PHTHALATE				
BORON				
BROMODICHLOROMETHANE	6.6E-02	1.1E-01	6.6E+01	2.2E+02
BROMOFORM				
BROMOMETHANE	1.0E+00	1.4E+00	1.0E+03	2.9E+03
CADMIUM				
CARBON TETRACHLORIDE	5.7E-02	9.5E-02	5.7E+01	1.9E+02
CHLORDANE				
CHLOROANILINE, p-				
CHLOROBENZENE	1.2E+01	1.7E+01	1.2E+04	3.5E+04
CHLOROETHANE	2.9E+00	4.9E+00	2.9E+03	9.9E+03
CHLOROFORM	4.5E-01	7.5E-01	4.5E+02	1.5E+03
CHLOROMETHANE	3.3E-01	5.5E-01	3.3E+02	1.1E+03
CHLOROPHENOL, 2-	3.7E+00	5.1E+00	3.7E+03	1.0E+04
CHROMIUM (Total)				
CHROMIUM III				
CHROMIUM VI				
CHRYSENE				
COBALT				
COPPER				
CYANIDE (Free)				
DIBENZO(a,h)ANTHTRACENE				
DIBROMOCHLOROMETHANE	9.1E-02	1.5E-01	9.1E+01	3.0E+02
1,2-DIBROMO-3-CHLOROPROPANE	1.2E-03	2.0E-03	1.2E+00	4.1E+00
DIBROMOETHANE, 1,2-	3.4E-02	5.7E-02	3.4E+01	1.1E+02
DICHLOROBENZENE, 1,2-	4.2E+01	5.8E+01	4.2E+04	1.2E+05

TABLE E. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Indoor Air and Soil Gas
(Vapor Intrusion Concerns)

CHEMICAL PARAMETER	INDOOR AIR SCREENING LEVELS		[2]SHALLOW SOIL GAS SCREENING LEVELS	
	[1]Residential Land Use (ug/m3)	Commercial/ Industrial Land Use Only (ug/m^3)	[1]Residential Land Use (ug/m3)	Commercial/ Industrial Land Use Only (ug/m^3)
DICHLOROBENZENE, 1,3-	2.2E+01	3.1E+01	2.2E+04	6.1E+04
DICHLOROBENZENE, 1,4-	2.1E-01	3.6E-01	2.1E+02	7.2E+02
DICHLOROBENZIDINE, 3,3-				
DICHLORODIPHENYLDICHLOROETHANE (DDD)				
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)				
DICHLORODIPHENYLTRICHLOROETHANE (DDT)				
DICHLOROETHANE, 1,1-	1.5E+00	2.5E+00	1.5E+03	5.0E+03
DICHLOROETHANE, 1,2-	1.2E-01	2.0E-01	1.2E+02	3.9E+02
DICHLOROETHYLENE, 1,1-	4.2E+01	5.8E+01	4.2E+04	1.2E+05
DICHLOROETHYLENE, Cis 1,2-	7.3E+00	1.0E+01	7.3E+03	2.0E+04
DICHLOROETHYLENE, Trans 1,2-	1.5E+01	2.0E+01	1.5E+04	4.1E+04
DICHLOROPHENOL, 2,4-				
DICHLOROPROPANE, 1,2-	2.4E-01	4.0E-01	2.4E+02	7.9E+02
DICHLOROPROPENE, 1,3-	1.5E-01	2.6E-01	1.5E+02	5.2E+02
DIELDRIN				
DIETHYLPHTHALATE				
DIMETHYLPHTHALATE				
DIMETHYLPHENOL, 2,4-	1.5E+01	2.0E+01	1.5E+04	4.1E+04
DINITROPHENOL, 2,4-				
DINITROTOLUENE, 2,4-				
1,4 DIOXANE				
DIOXIN (2,3,7,8-TCDD)				
ENDOSULFAN				
ENDRIN				
ETHANOL			1.9E+07	3.8E+07
ETHYLBENZENE	4.2E+02	5.8E+02	4.2E+05	1.2E+06
FLUORANTHENE				
FLUORENE	2.9E+01	4.1E+01	2.9E+04	8.2E+04
HEPTACHLOR				
HEPTACHLOR EPOXIDE				
HEXACHLOROBENZENE				
HEXACHLOROBUTADIENE				
HEXACHLOROCYCLOHEXANE (gamma) LINDANE				
HEXACHLOROETHANE				
INDENO(1,2,3-cd)PYRENE				
LEAD				
MERCURY	1.9E-02	2.7E-02	1.9E+01	5.3E+01
METHOXYCHLOR				
METHYLENE CHLORIDE	2.4E+00	4.1E+00	2.4E+03	8.2E+03
METHYL ETHYL KETONE	2.1E+02	3.0E+02	2.1E+05	5.9E+05
METHYL ISOBUTYL KETONE	1.7E+01	2.4E+01	1.7E+04	4.7E+04
METHYL MERCURY				
METHYLNAPHTHALENE (total 1- & 2-)	2.9E+01	4.1E+01	2.9E+04	8.2E+04
METHYL TERT BUTYL ETHER	9.4E+00	1.6E+01	9.4E+03	3.1E+04

TABLE E. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Indoor Air and Soil Gas
(Vapor Intrusion Concerns)

	INDOOR AIR SCREENING LEVELS		[2]SHALLOW SOIL GAS SCREENING LEVELS	
CHEMICAL PARAMETER	[1]Residential Land Use (ug/m3)	Commercial/ Industrial Land Use Only (ug/m^3)	[1]Residential Land Use (ug/m3)	Commercial/ Industrial Land Use Only (ug/m^3)
MOLYBDENUM				
NAPHTHALENE	7.1E-02	1.2E-01	7.1E+01	2.4E+02
NICKEL				
PENTACHLOROPHENOL				
PERCHLORATE				
PHENANTHRENE	2.9E+01	4.1E+01	2.9E+04	8.2E+04
PHENOL				
POLYCHLORINATED BIPHENYLS (PCBs)				
PYRENE	2.2E+01	3.1E+01	2.2E+04	6.1E+04
SELENIUM				
SILVER				
STYRENE	2.1E+02	3.0E+02	2.1E+05	5.9E+05
tert-BUTYL ALCOHOL	2.6E+00	4.3E+00	2.6E+03	8.7E+03
TETRACHLOROETHANE, 1,1,1,2-	3.3E-01	5.5E-01	3.3E+02	1.1E+03
TETRACHLOROETHANE, 1,1,2,2-	4.3E-02	7.2E-02	4.3E+01	1.4E+02
TETRACHLOROETHYLENE	4.1E-01	6.8E-01	4.1E+02	1.4E+03
THALLIUM				
TOLUENE	6.3E+01	8.8E+01	6.3E+04	1.8E+05
TOXAPHENE				
TPH (gasolines)	2.6E+01	3.6E+01	2.6E+04	7.2E+04
TPH (middle distillates)	2.6E+01	3.6E+01	2.6E+04	7.2E+04
TPH (residual fuels)				
TRICHLOROBENZENE, 1,2,4-	7.3E-01	1.0E+00	7.3E+02	2.0E+03
TRICHLOROETHANE, 1,1,1-	4.6E+02	6.4E+02	4.6E+05	1.3E+06
TRICHLOROETHANE, 1,1,2-	1.5E-01	2.5E-01	1.5E+02	5.0E+02
TRICHLOROETHYLENE	1.2E+00	2.0E+00	1.2E+03	4.1E+03
TRICHLOROPHENOL, 2,4,5-	7.3E+01	1.0E+02	7.3E+04	2.0E+05
TRICHLOROPHENOL, 2,4,6-				
VANADIUM				
VINYL CHLORIDE	3.2E-02	5.3E-02	3.2E+01	1.1E+02
XYLENES	1.5E+02	2.0E+02	1.5E+05	4.1E+05
ZINC				

TABLE E. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Indoor Air and Soil Gas
(Vapor Intrusion Concerns)

	INDOOR AIR SCREENING LEVELS		[2]SHALLOW SOIL GAS SCREENING LEVELS	
CHEMICAL PARAMETER	**[1]Residential Land Use (ug/m3)**	**Commercial/ Industrial Land Use Only (ug/m^3)**	**[1]Residential Land Use (ug/m3)**	**Commercial/ Industrial Land Use Only (ug/m^3)**
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	not applicable	not applicable	not apploicable	not applicable
Sodium Adsorption Ratio	not applicable	not applicable	not applicable	not applicable

Red: Updated with respect to ESLs presented in July 2003 document.

Notes:

1. Category "Residential Land Use" generally considered adequate for other sensitive uses (e.g., day-care centers, hospitals, etc.)
2. Soil Gas: Screening levels based on soil gas data collected less than 1.5 meters (five feet) below a building foundation or the ground surface. Intended for evaluation of potential indoor-air impacts.

Soil gas data should be collected and evaluated at all sites with significant areas of VOC-impacted soil. Screening levels also apply to areas over of impacted groundwater.

Source of soil ESLs: Refer to Tables E-2 and E-3 in Appendix 1.

TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Volume 1, Section 2.2 and Appendix 1, Chapter 5.

TABLE F: SURFACE WATER

TABLE F. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Surface Water Bodies

CHEMICAL PARAMETER	SURFACE WATER SCREENING LEVELS [1]Freshwater (ug/L)	[2]Marine (ug/L)	[3]Estuarine (ug/L)
ACENAPHTHENE	2.0E+01	2.0E+01	2.0E+01
ACENAPHTHYLENE	3.0E+01	3.0E+01	3.0E+01
ACETONE	1.5E+03	1.5E+03	1.5E+03
ALDRIN	1.4E-04	1.4E-04	1.4E-04
ANTHRACENE	7.3E-01	7.3E-01	7.3E-01
ANTIMONY	6.0E+00	5.0E+02	3.0E+01
ARSENIC	1.4E-01	1.4E-01	1.4E-01
BARIUM	1.0E+03	1.0E+03	1.0E+03
BENZENE	1.0E+00	7.1E+01	4.6E+01
BENZO(a)ANTHRACENE	2.7E-02	2.7E-02	2.7E-02
BENZO(b)FLUORANTHENE	2.9E-02	2.9E-02	2.9E-02
BENZO(k)FLUORANTHENE	2.9E-02	4.9E-02	4.9E-02
BENZO(g,h,i)PERYLENE	1.0E-01	1.0E-01	1.0E-01
BENZO(a)PYRENE	1.4E-02	1.4E-02	1.4E-02
BERYLLIUM	2.7E+00	2.7E+00	2.7E+00
BIPHENYL, 1,1-	5.0E-01	5.0E-01	5.0E-01
BIS(2-CHLOROETHYL)ETHER	1.4E-02	1.4E+00	1.4E+00
BIS(2-CHLOROISOPROPYL)ETHER	5.0E-01	6.1E+01	6.1E+01
BIS(2-ETHYLHEXYL)PHTHALATE	4.0E+00	5.9E+00	5.9E+00
BORON	1.6E+00	1.6E+00	1.6E+00
BROMODICHLOROMETHANE	1.0E+02	3.2E+03	3.2E+03
BROMOFORM	1.0E+02	3.6E+02	3.6E+02
BROMOMETHANE	9.8E+00	3.2E+03	1.6E+02
CADMIUM	1.1E+00	9.3E+00	1.1E+00
CARBON TETRACHLORIDE	5.0E-01	4.4E+00	4.4E+00
CHLORDANE	5.9E-04	5.9E-04	5.9E-04
CHLOROANILINE, p-	5.0E+00	5.0E+00	5.0E+00
CHLOROBENZENE	2.5E+01	5.0E+01	2.5E+01
CHLOROETHANE	1.2E+01	1.2E+01	1.2E+01
CHLOROFORM	7.0E+01	4.7E+02	4.7E+02
CHLOROMETHANE	1.3E+00	3.2E+03	3.2E+03
CHLOROPHENOL, 2-	1.8E-01	1.8E-01	1.8E-01
CHROMIUM (Total)	5.0E+01	1.8E+02	1.8E+02
CHROMIUM III	1.8E+02	1.8E+02	1.8E+02
CHROMIUM VI	1.1E+01	5.0E+01	1.1E+01
CHRYSENE	4.9E-02	4.9E-02	4.9E-02
COBALT	3.0E+00	3.0E+00	3.0E+00
COPPER	9.0E+00	3.1E+00	3.1E+00
CYANIDE (Free)	5.2E+00	1.0E+00	1.0E+00
DIBENZO(a,h)ANTHTRACENE	8.5E-03	4.9E-02	4.9E-02
DIBROMOCHLOROMETHANE	4.6E+01	4.6E+01	4.6E+01
1,2-DIBROMO-3-CHLOROPROPANE	2.0E-01	2.0E-01	2.0E-01
DIBROMOETHANE, 1,2-	5.0E-02	1.4E+03	1.4E+03
DICHLOROBENZENE, 1,2-	1.0E+01	1.0E+01	1.0E+01
DICHLOROBENZENE, 1,3-	7.1E+01	6.5E+01	6.5E+01
DICHLOROBENZENE, 1,4-	5.0E+00	1.1E+01	1.1E+01
DICHLOROBENZIDINE, 3,3-	2.9E-02	7.7E-02	7.7E-02

TABLE F. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Surface Water Bodies

CHEMICAL PARAMETER	SURFACE WATER SCREENING LEVELS [1]Freshwater (ug/L)	[2]Marine (ug/L)	[3]Estuarine (ug/L)
DICHLORODIPHENYLDICHLOROETHANE (DDD)	8.4E-04	8.4E-04	8.4E-04
DICHLORODIPHENYLDICHLOROETHYLENE (DDE)	5.9E-04	5.9E-04	5.9E-04
DICHLORODIPHENYLTRICHLOROETHANE (DDT)	5.9E-04	5.9E-04	5.9E-04
DICHLOROETHANE, 1,1-	5.0E+00	4.7E+01	4.7E+01
DICHLOROETHANE, 1,2-	5.0E-01	9.9E+01	9.9E+01
DICHLOROETHYLENE, 1,1-	3.2E+00	3.2E+00	3.2E+00
DICHLOROETHYLENE, Cis 1,2-	6.0E+00	5.9E+02	5.9E+02
DICHLOROETHYLENE, Trans 1,2-	1.0E+01	2.6E+02	2.6E+02
DICHLOROPHENOL, 2,4-	3.0E-01	3.0E-01	3.0E-01
DICHLOROPROPANE, 1,2-	5.0E+00	1.0E+01	1.0E+01
DICHLOROPROPENE, 1,3-	5.0E-01	1.2E+02	1.2E+02
DIELDRIN	2.2E-03	1.9E-03	1.9E-03
DIETHYLPHTHALATE	1.5E+00	1.7E+00	1.5E+00
DIMETHYLPHTHALATE	1.5E+00	1.7E+00	1.5E+00
DIMETHYLPHENOL, 2,4-	1.0E+02	1.1E+02	1.1E+02
DINITROPHENOL, 2,4-	1.4E+01	7.5E+01	7.5E+01
DINITROTOLUENE, 2,4-	1.1E-01	9.1E+00	9.1E+00
1,4 DIOXANE	3.0E+00	5.0E+04	5.0E+04
DIOXIN (2,3,7,8-TCDD)	1.4E-08	1.4E-08	1.4E-08
ENDOSULFAN	5.6E-02	8.7E-03	8.7E-03
ENDRIN	3.6E-02	2.3E-03	2.3E-03
ETHANOL	5.0E+04	5.0E+04	5.0E+04
ETHYLBENZENE	3.0E+01	3.0E+01	3.0E+01
FLUORANTHENE	8.1E+00	8.0E+00	8.0E+00
FLUORENE	3.9E+00	3.9E+00	3.9E+00
HEPTACHLOR	2.1E-04	2.1E-04	2.1E-04
HEPTACHLOR EPOXIDE	1.1E-04	1.1E-04	1.1E-04
HEXACHLOROBENZENE	7.7E-04	7.7E-04	7.7E-04
HEXACHLOROBUTADIENE	2.1E-01	4.7E+00	4.7E+00
HEXACHLOROCYCLOHEXANE (gamma) LINDANE	6.3E-02	6.3E-02	6.3E-02
HEXACHLOROETHANE	7.0E-01	8.9E+00	8.9E+00
INDENO(1,2,3-cd)PYRENE	2.9E-02	2.9E-02	2.9E-02
LEAD	2.5E+00	8.1E+00	2.5E+00
MERCURY	1.2E-02	2.5E-02	1.2E-02
METHOXYCHLOR	1.9E-02	1.9E-02	1.9E-02
METHYLENE CHLORIDE	5.0E+00	1.6E+03	1.6E+03
METHYL ETHYL KETONE	4.2E+03	8.4E+03	8.4E+03
METHYL ISOBUTYL KETONE	1.2E+02	1.7E+02	1.7E+02
METHYL MERCURY	3.0E-03	3.0E-03	3.0E-03
METHYLNAPHTHALENE (total 1- & 2-)	2.1E+00	2.1E+00	2.1E+00
METHYL TERT BUTYL ETHER	5.0E+00	1.8E+02	1.8E+02
MOLYBDENUM	3.5E+01	2.4E+02	2.4E+02
NAPHTHALENE	1.7E+01	2.1E+01	2.1E+01
NICKEL	5.2E+01	8.2E+00	8.2E+00
PENTACHLOROPHENOL	1.0E+00	7.9E+00	7.9E+00
PERCHLORATE	6.0E+00	6.0E+02	6.0E+02
PHENANTHRENE	6.3E+00	4.6E+00	4.6E+00

TABLE F. ENVIRONMENTAL SCREENING LEVELS (ESLs)
Surface Water Bodies

CHEMICAL PARAMETER	SURFACE WATER SCREENING LEVELS [1]Freshwater (ug/L)	[2]Marine (ug/L)	[3]Estuarine (ug/L)
PHENOL	5.0E+00	1.3E+03	1.3E+03
POLYCHLORINATED BIPHENYLS (PCBs)	1.7E-04	1.7E-04	1.7E-04
PYRENE	2.0E+00	2.0E+00	2.0E+00
SELENIUM	5.0E+00	7.1E+01	5.0E+00
SILVER	3.4E-01	1.9E-01	1.9E-01
STYRENE	1.0E+01	1.1E+01	1.1E+01
tert-BUTYL ALCOHOL	1.2E+01	1.8E+04	1.8E+04
TETRACHLOROETHANE, 1,1,1,2-	1.3E+00	9.3E+02	9.3E+02
TETRACHLOROETHANE, 1,1,2,2-	1.0E+00	1.1E+01	1.1E+01
TETRACHLOROETHYLENE	5.0E+00	8.9E+00	8.9E+00
THALLIUM	2.0E+00	6.3E+00	6.3E+00
TOLUENE	4.0E+01	4.0E+01	4.0E+01
TOXAPHENE	2.0E-04	2.0E-04	2.0E-04
TPH (gasolines)	1.0E+02	3.7E+03	5.0E+02
TPH (middle distillates)	1.0E+02	6.4E+02	6.4E+02
TPH (residual fuels)	1.0E+02	6.4E+02	6.4E+02
TRICHLOROBENZENE, 1,2,4-	2.5E+01	6.5E+01	2.5E+01
TRICHLOROETHANE, 1,1,1-	6.2E+01	6.2E+01	6.2E+01
TRICHLOROETHANE, 1,1,2-	5.0E+00	4.2E+01	4.2E+01
TRICHLOROETHYLENE	5.0E+00	8.1E+01	8.1E+01
TRICHLOROPHENOL, 2,4,5-	6.3E+01	1.1E+01	1.1E+01
TRICHLOROPHENOL, 2,4,6-	5.0E-01	6.5E+00	6.5E+00
VANADIUM	1.5E+01	1.9E+01	1.9E+01
VINYL CHLORIDE	5.0E-01	5.3E+02	5.3E+02
XYLENES	2.0E+01	1.0E+02	1.0E+02
ZINC	1.2E+02	8.1E+01	8.1E+01
Electrical Conductivity (mS/cm, USEPA Method 120.1 MOD)	not applicable	not applicable	not applicable
Sodium Adsorption Ratio	not applicable	not applicable	not applicable

Red: Updated with respect to ESLs presented in July 2003 document.

Notes:

1. Source of Freshwater ESLs: Refer to Appendix 1, Table F-2a
2. Source of Marine ESLs: Refer to Appendix 1, Table F-2b.
3. Source of Estuarine ESLs: Refer to Appendix 1, Table F-2c.

Surface water screening levels lowest of drinking water goal (freshwater only), chronic aquatic habitat goal, goal to address bioaccumulation in aquatic organisms and subsequent consumption by humans, and general nuisance goal (odors, etc.). Refer to Section 2.7 of text for discussion.

Estuarine screening levels lowest of freshwater and marine screening levels.

Water ESLs for ethanol based on gross contamination concerns (see Appendix 1, Chapter 5 and related tables).

TPH -Total Petroleum Hydrocarbons. TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, PAHs, oxidizers, etc.). See Section 2.2 and Appendix 1, Chapter 5.